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FIELD GUIDE No. 8

TENTH INTERNATIONAL SYMPOSIUM ON OSTRACODA ABERYSTWYTH 1988

RECENT AND QUATERNARY OSTRACODA OF THE FIRTH OF CLYDE, SW SCOTLAND

J.E. WHITTAKER

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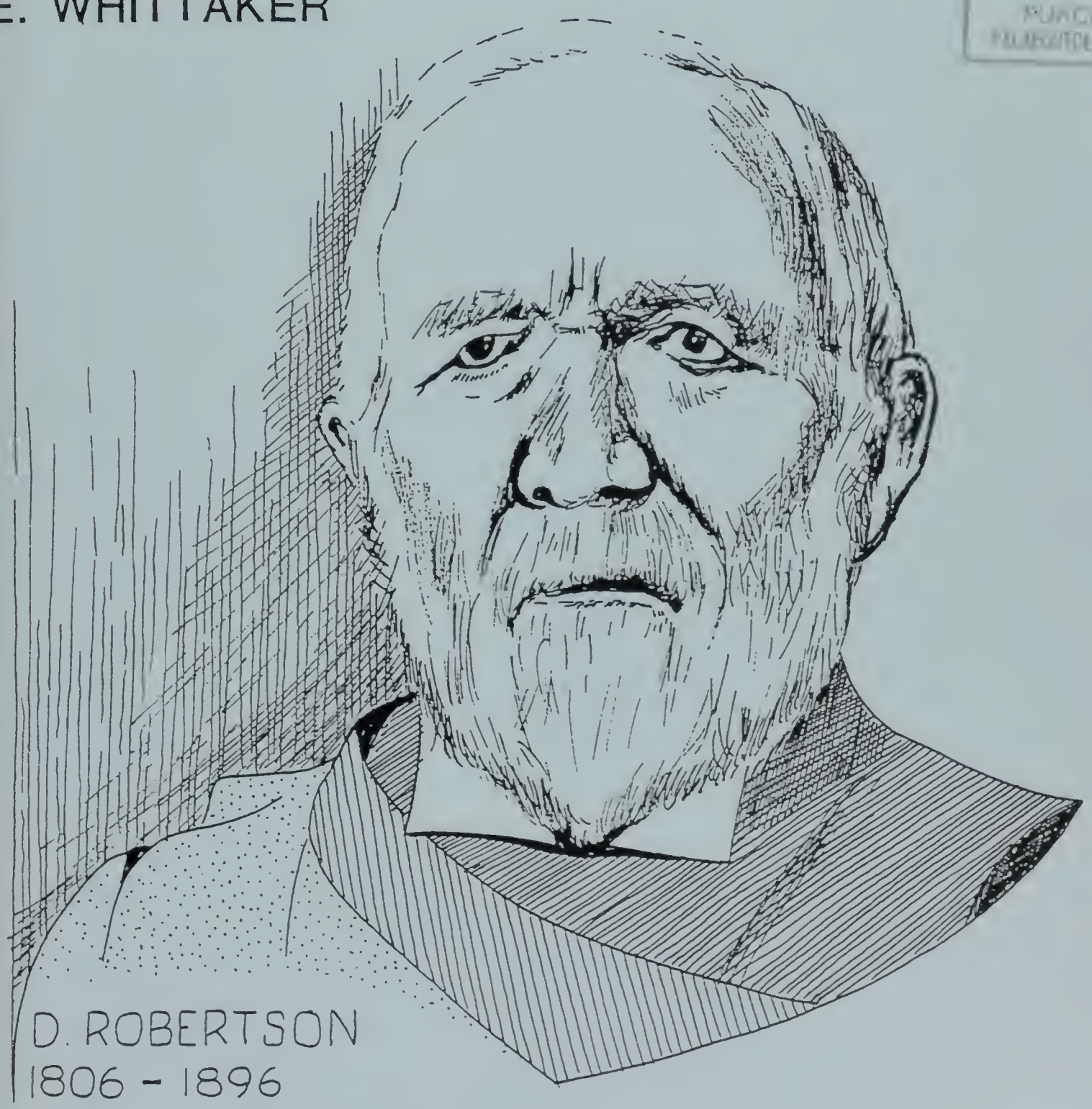

D. ROBERTSON
1806 - 1896

SCHOOL OF EARTH SCIENCES

THAMES
Polytechnic
L·O·N·D·O·N

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RECENT & QUATERNARY OSTRACODA OF THE FIRTH OF CLYDE, SOUTHWEST SCOTLAND

John E. Whittaker

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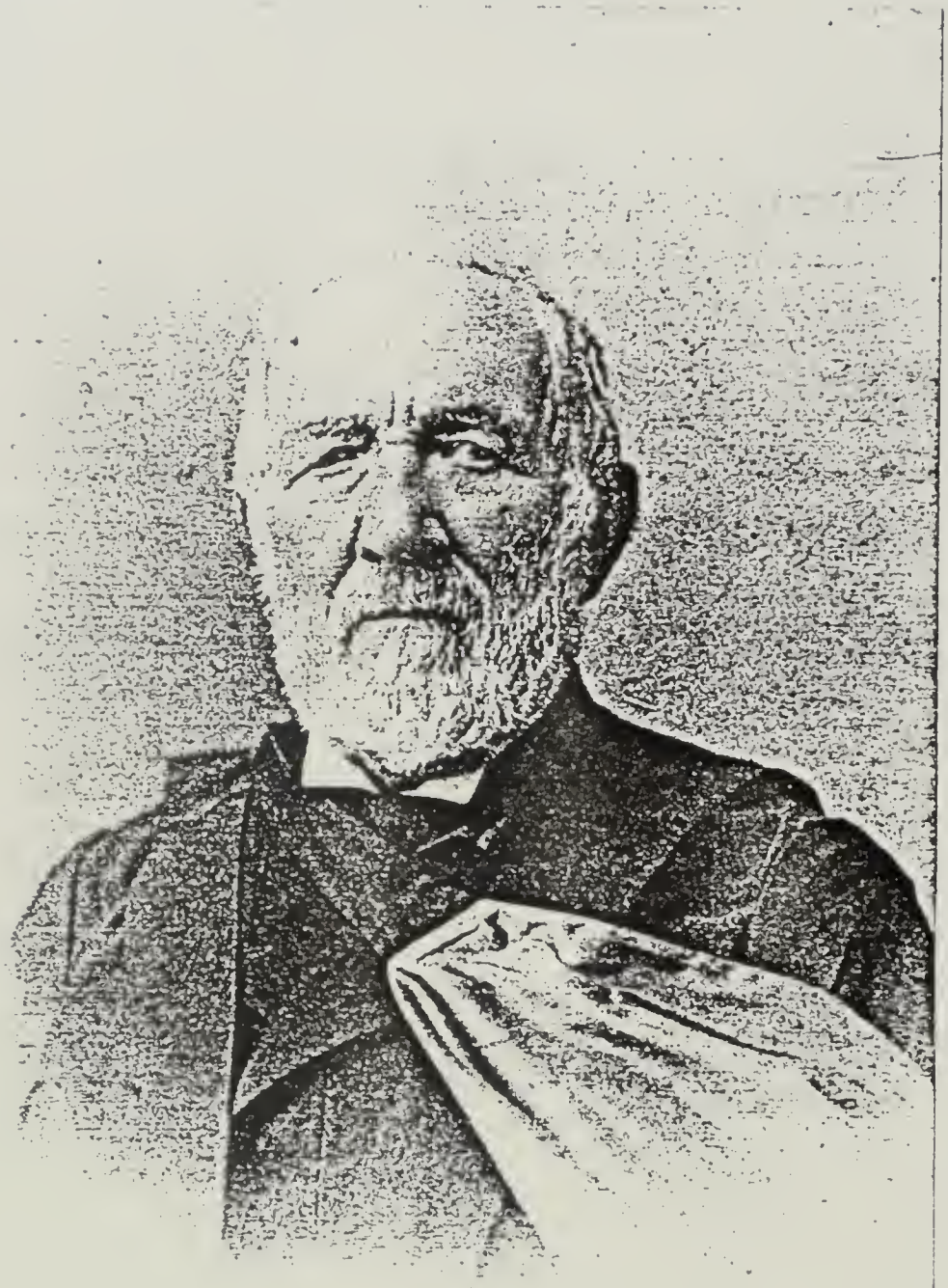

RECENT & QUATERNARY OSTRACODA OF THE FIRTH OF CLYDE, SOUTHWEST SCOTLAND

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The theme of this excursion is a nostalgic visit to the haunts of the eminent Cumbrae naturalist, David Robertson. In tracing his footsteps, we will also visit one of the most famous collecting areas for British Recent and Quaternary Ostracoda - sites frequented also by Robertson's friends George Stewardson Brady, Rev. Alfred Merle Norman and Rev. Henry Crosskey. As a result, it is not surprising that the type localities of many Recent and Quaternary ostracods are to be found in the Firth of Clyde area.

The Guidebook is also written as a tribute to Robertson and on pp. 22, 23 I have given a short biography of the man who many now believe has never received the same recognition as his illustrious compatriots, Brady and Norman, but deserves it nonetheless.

In 1875 Robertson published a major paper in the Transactions of the Geological Society of Glasgow on the Recent Ostracoda and Foraminifera of the Firth of Clyde. In it he records the distribution of 90 species of podocopid ostracods from 40 localities, either collected from the littoral by hand or by the use of the dredge from deeper water. (Fig. 5 shows (black circles) his localities around Cumbrae and we will visit several of them either from land or by boat). Information on the distribution of the species in the area and further afield is given by Robertson and under each locality much detail on the site of the sample locality, its depth, substrate-type and characteristic fauna listed. This classic, but little known paper, also includes a four-page appendix on collecting, processing and mounting techniques for ostracods, most of which would, even today, not be out of place in a techniques chapter of a good micropalaeontology textbook.

Whilst planning this excursion, collecting of the Recent littoral and sublittoral sites was undertaken in May 1987. Therefore the ostracod species found and listed in this Guidebook will not necessarily be the same as you will find them in August 1988. It will be interesting to see the difference. The faunal lists given on pp. 32-38 for the deepwater samples were composed from samples kindly provided by Drs M.C. Keen and J.E. Robinson. These were included as most of them were collected at the actual sites visited by Robertson and his friends over a century ago. Very few species were actually live at the time of collection, but this is merely a reflection of the sampling methods.

Frontespiece: Photograph of David Robertson, believed to have been taken on the occasion of his receiving the honorary degree of Doctor of Laws at the University of Glasgow in 1894.

FIELD EXCURSION ITINERARY

Monday, 1st August. a.m. FIRST PARTY (maximum 11 people) - half-day session on research vessel 'APLYSIA'. Grab sampling in the Firth of Clyde around the Cumbrae Isles and the Island of Bute. SECOND PARTY - sampling littoral rockpools (STOPS R1-R4)(pp. 9,10) and Quaternary raised beach (STOP Q1) on Great Cumbrae (localities shown on Figs 1, 5). p.m. Reverse of morning session, FIRST PARTY sampling rockpools, etc. SECOND PARTY on the 'APLYSIA'. It is suggested that the morning and afternoon cruises on the 'APLYSIA' each sample different areas, so that material can be shared and that way, coverage maximized. Sites recommended are some of the favoured dredging localities of Robertson and his friends, notably The Tan, Fairlie Roads and off NW Cumbrae (see black circles on Figs 5, 6).

Tuesday, 2nd August. Ferry from Wemyss Bay to the Isle of Bute. Recent sampling (littoral and sublittoral) (STOPS R5-R7) (p. 10) and Quaternary raised beach of Bute (STOP Q2)(pp. 17,18). Ferry to mainland (Colintraive). Collect in Loch Long and Loch Fyne (sea-lochs); Recent littoral, marine and brackish (STOPS R8, R9). (All sites shown in Fig. 1). Scenic drive back to Millport, via Loch Lomond and Glasgow.

Wednesday, 3rd August. a.m. Ferry to Largs. Collect from rocky coast rock-pools between Ardrossan and Seamill on mainland (STOP R10). (Locality on Fig. 1). p.m. Laboratory time at Millport Laboratory. Examining collected samples, identifying Ostracoda and concentrating residues to take home.

The tides during our stay will <u>not</u> be convenient! Low Water (which is necessary in order to sample some rockpools and sublittoral algae) is around 8/9 a.m. and 8/9 p.m. each day. We will therefore have to start early and, should the tides be too high for sampling in the early afternoon, further trips can be accommodated in the evening as it will still be light. This, at least, will be possible around Cumbrae Island. There will be plenty of time otherwise in the evenings for working on the material in the Laboratory.

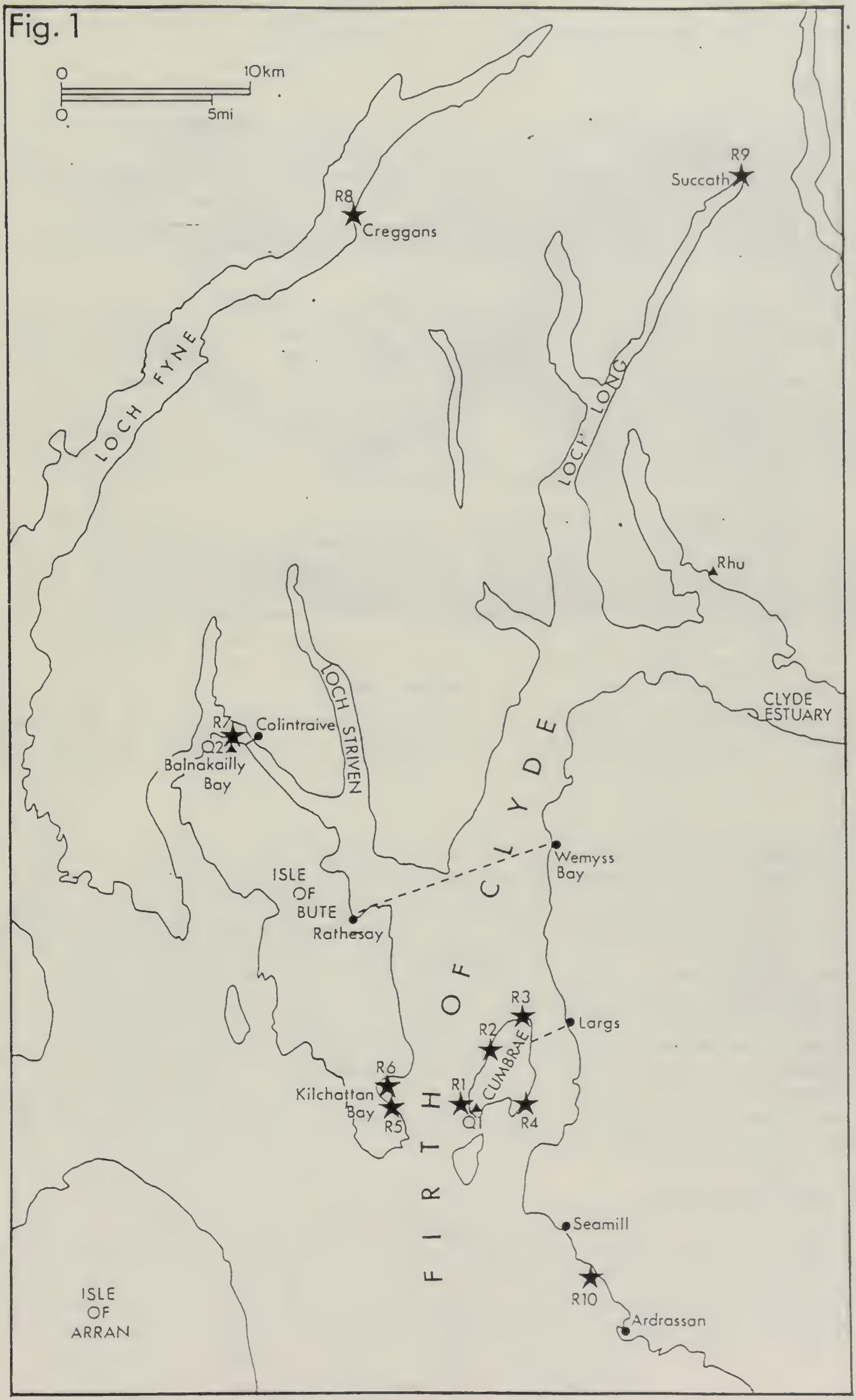
For the record the times of the tides are as follows:

1.8.1988	High Water	2.15 a.m. and 2.52 p.m.
	Low Water	7.46 a.m. and 8.06 p.m.
2.8.1988	High Water	3.00 a.m. and 3.34 p.m.
	Low Water	8.33 a.m. and 8.52 p.m.
3.8.1988	High Water	3.42 a.m. and 4.14 p.m.
	Low Water	9.21 a.m. and 9.39 p.m.

The taxonomy used in this Guidebook follows Athersuch <u>et al</u>. (in press), the forthcoming revision of all the Recent Ostracoda of British coastal waters; from it are also freely borrowed the chapter entitled 'General notes on the Ecology of British Coastal Ostracoda' and the drawings in Plates 1-6.

Fig. 1 General locality map of the Firth of Clyde, showing collecting sites. Stars indicate Recent sites (STOPS R1-R10). Triangles are Quaternary sites (STOPS Q1, Q2); material from Rhu will be distributed to the party.

Fig. 1


0 10km
0 5mi
R8
Creggans
R9
Succath
LOCH FYNE
LOCH LONG
Rhu
CLYDE ESTUARY
R7
Q2
Colintraive
Balnakailly Bay
LOCH STRIVEN
Wemyss Bay
ISLE OF BUTE
Rathesay
FIRTH OF CLYDE
R3
R2
CUMBRAE
Largs
R6
Kilchattan Bay
R5
R1
Q1
R4
Seamill
R10
Ardrassan
ISLE OF ARRAN

THE FIRTH OF CLYDE AND CLYDE SEA AREA - AN INTRODUCTION.

HYDROGRAPHY

The Firth of Clyde, running almost north to south (at right angles to the actual Clyde Estuary)(Fig. 1), is in fact a southern extension of a complex of interconnected, glacially over-deepened drowned valleys and marine channels. The word 'Firth' is a Scottish term for a body of water, often estuarine, associated with drowned, glacially modified, lowland terrain in which great thicknesses of glacial and post-glacial sediments obscure much of the underlying rocks.

North of the Cumbraes the Firth of Clyde is quite narrow, attaining depths of 150m (over 80 fathoms) below sea-level to the south of the island of Bute (Fig. 2b). Geomorphologically, this Inner Firth (Figs 1, 2b) is transitional to the tributary sea-lochs which include Loch Long and Loch Striven. These sea-lochs are true fjords, with glacially overdeepened basins, terminating in a pronounced submarine 'bar', which results in a marked degree of hydrological isolation of the deeper lochs from the sea. Indeed, a fall of about 10m in sea level would cut off these lochs completely from saltwater influences.

South of the Cumbraes, between Arran and the Ayrshire coast, the Firth widens to become part of a great submarine rock-basin which originates at the outlet of Loch Fyne (Figs 1, 2b). The extent of this basin is partly a function of the size of the confluent ice-mass originating at the headwaters of these lochs and partly of the structural weakness of the underlying sedimentary rocks (Fig. 2a). The southern limit of the Firth is a broad zone of relatively shallow water (the 'Great Plateau'), some 35-75m/20-40 fathoms deep, which extends from southern Kintyre to the Ayshire coast.

In summary, the Firth of Clyde is a deep, sheltered waterway some 35km long, which compares very favourably with other British estuaries which are more open and exposed.

SEDIMENTS

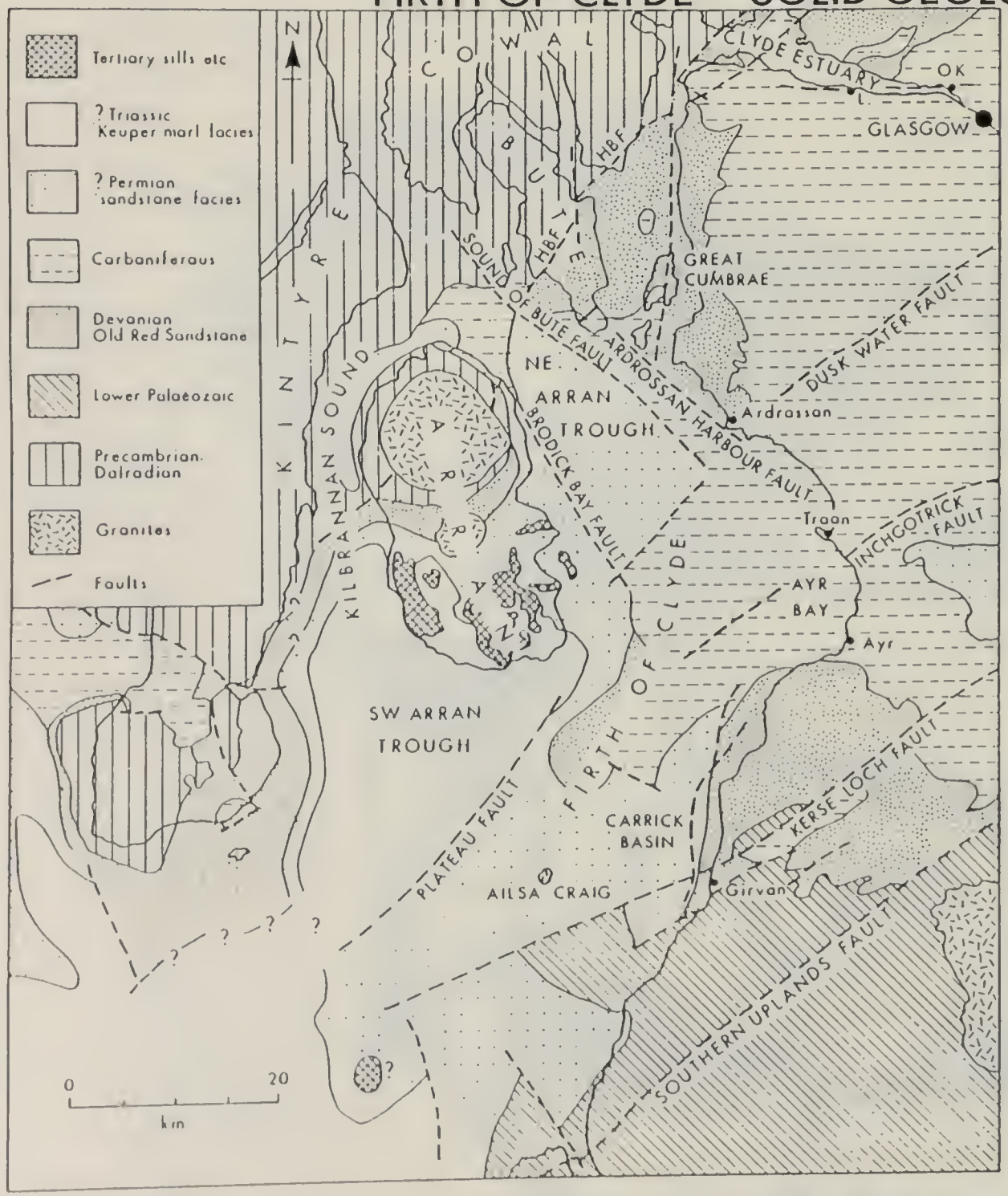
The sediments of the Firth of Clyde and Clyde Sea area are shown in two different ways in Fig. 3, based on the work of Deegan et al. (1973). There are three main facies which are closely related to water depth. The coarse littoral facies contains clean sands and sediments containing gravel; this extends from high water to about 40m depth. The transitional facies has a wide range of grain size and a somewhat limited distribution, except in the inner Clyde Estuary. The deep silty clay facies, in terms of area, is the most common facies, but is found only in the deeper parts of the area (marked as M or as mud on Fig. 3). According to various studies the coarse littoral facies contains the most diverse faunas, the transitional facies is intermediate, and the silty clay facies contains the least diverse faunas. The coarse littoral facies sediments vary in thickness from zero to a few centimetres, but the sediments of the deep silty clay facies are much thicker.

SALINITY AND TEMPERATURE

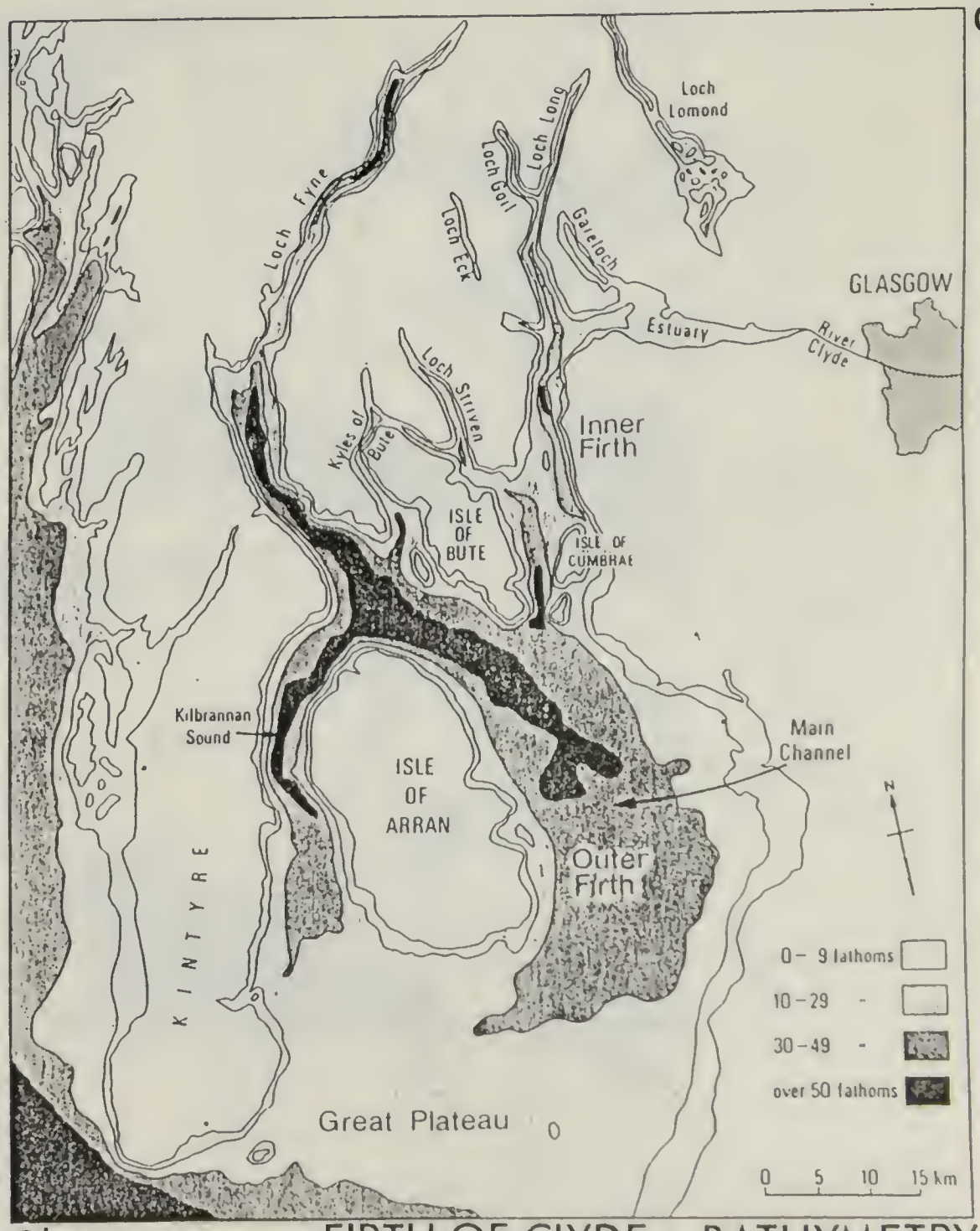
The winter and summer salinity and temperature distributions at 5m depth are shown in Fig. 4. The Firth of Clyde and Clyde Sea area is always fresher than the North Channel (sea between Northern Ireland and Scotland). In the surface waters there are occasional hints of a relatively fresh outflow from the Inner Firth, of greater continuity of properties particularly temperature, along the eastern coasts of the Firth than the western, and of a patchy distribution

Fig. 2a, after McLean & Deegan (1978); fig. 2b, after Hunter (1958).

Fig. 2

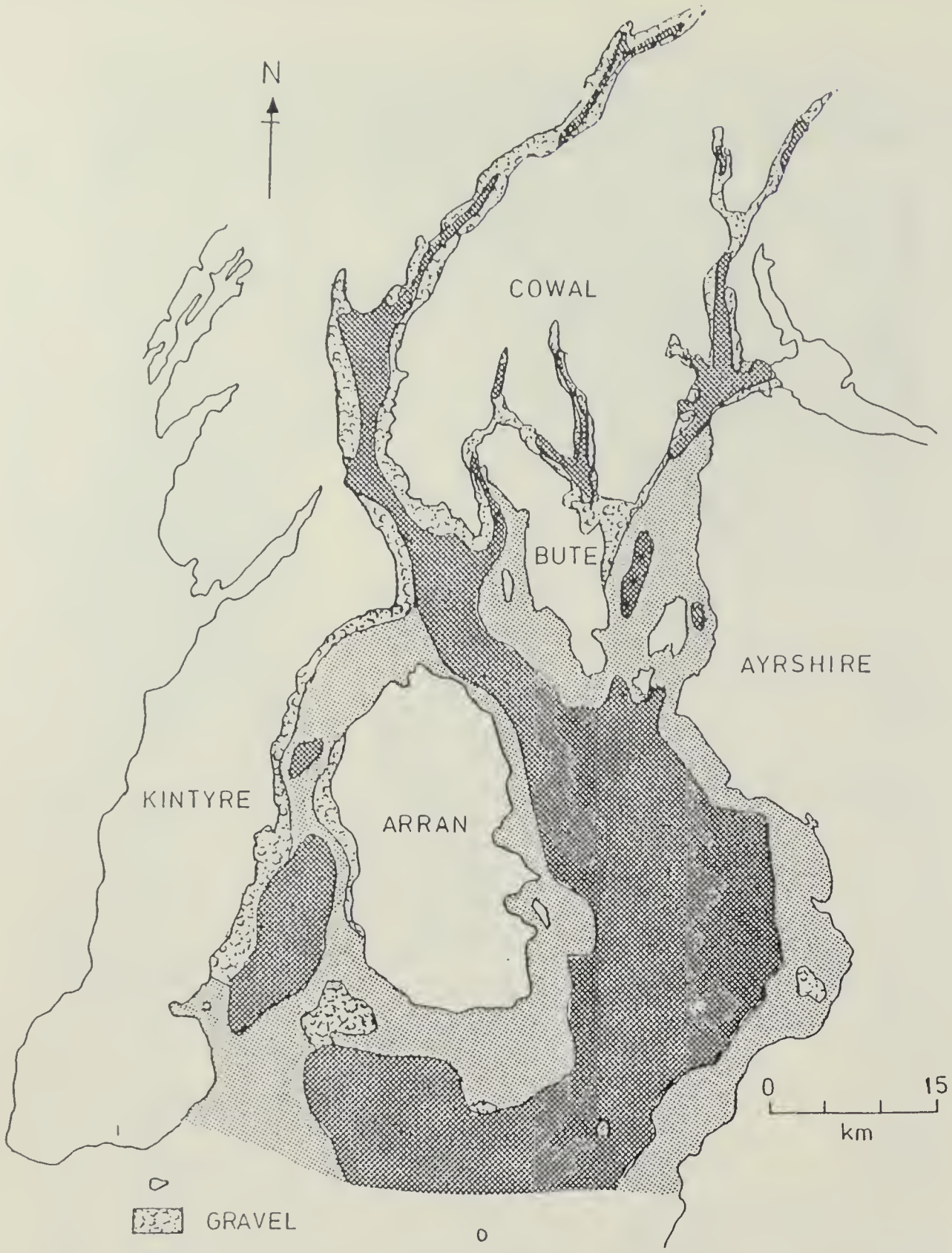


2a Simplified map of the solid geology of the Clyde Sea Area, showing the locations of major rock outcrops and known or conjectural faults; the (Loch Doon) granite to the southeast of the Southern Uplands Fault is Siluro-Devonian in age; the Arran granites and the Ailsa Craig microgranite are Tertiary in age. Abbreviations: HBF Highland Boundary Fault; L. Langbank, O.K. Old Kilpatrick, adapted from McLean & Deegan 1978, figs. 1.1 and 8.1.



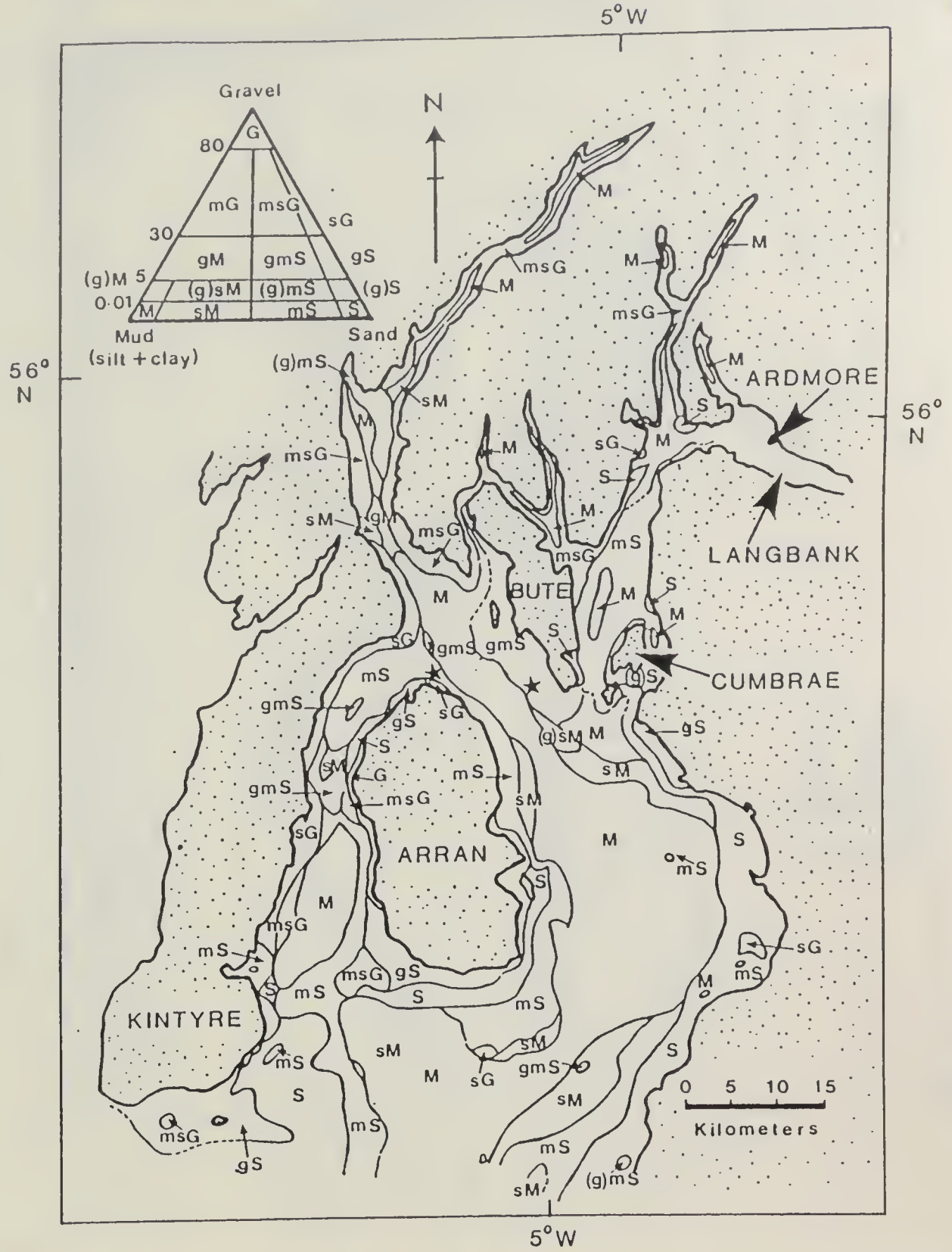
2b FIRTH OF CLYDE - BATHYMETRY

Figs 3a, b, after Deegan *et al.* (1973).



3a

FIRTH OF CLYDE - SEDIMENT



3b Surface sediment distribution in the Firth of Clyde area (modified from Deegan *et al.* 1973); G gravel, g gravelly, (g) slightly gravelly, S sand, s sandy, M mud, m muddy, * Lamon

Fig. 4

Winter and summer distributions of surface temperature and salinity; the salinity in the Outer Firth is always depressed by runoff although the influence of the Inner Firth is minimal; there is a front on the Great Plateau.

FIRTH OF CLYDE - SALINITY & TEMPERATURE

after Edwards et al. (1986).

within the Clyde Sea. The most prominent feature is along the Great Plateau (see Fig. 2b) where strong horizontal gradients, particularly of salinity, indicate the position of the front.

The front on the Great Plateau separates tidally mixed water of the North Channel from quieter, less saline surface layers of the Outer Firth; there is estimated to be a residence time of about two months in the Outer Firth's surface layers. The position of the front is determined by the balance of mixing and buoyancy supply. The wind also modulates the weak tidal currents in the Outer Firth by driving surface currents and setting up deeper compensation flows. Deep water in the Arran Deep and Kilbrannan Sound (to the east and west of the Isle of Arran respectively) is irregularly renewed by inflow of dense water over the eastern part of the Great Plateau from autumn to spring but stagnates in summer below a thermocline. A minor part of this renewal only comes over the Davaar Sill into Kilbrannan Sound.

Bottom water of the fjordic sea-lochs is isolated in summer and renewed during the winter. The renewals occur by density currents flowing in from the sills and these produce a characteristic grading of the bottom sediments from coarse to fine away from the sills.

The salinity of the open sea around Bute and Cumbrae in August is usually around 32-33^{o}/oo, sea temperatures at the surface around 13^{o}C (Fig. 4).

-oOo-

RECENT OSTRACODA OF THE FIRTH OF CLYDE

LITTORAL AND SUBLITTORAL SAMPLES.

During fieldwork undertaken by the author and Drs Horne & Keen in late May 1987 many sites in the Firth of Clyde area were visited and collections made from marine algae and sediment scrapes. The best sampling sites will be re-visited in the course of this excursion (STOPS R1-R10). Depending on the state of the tide it is hoped to visit all of them. In addition to the sites we will visit on Cumbrae (STOPS R1-R4; Figs 1, 5) I have marked on Fig. 5 (black circles) several other localities which were sampled extensively a century ago by Robertson and his friends and which are listed in Robertson (1875). If time permits they can either be visited from the shore or by boat (see below for deeper water sites).

STOP R1 Eileann na Gourack, SW Great Cumbrae Island. Grid ref. NS 149 543. Locality shown in Figs 1, 5. Mixture of green, red (mostly Corallina) and brown algae with sand, shell-sand and mussel-bed was collected at mid-tide. Eleven species were recorded live (see Plates 1, 2), as follows:

Cythere lutea (O.F. Müller)
Hirschmannia viridis (O.F. Müller)(adults)
Xestoleberis aurantia (Baird)
Semicytherura nigrescens (Baird)
Callistocythere badia (Norman)
Paradoxostoma variabile (Baird)
Cytherois pusilla Sars
*Leptocythere baltica Klie
*Leptocythere lacertosa (Hirschmann)
*Semicytherura sella (Sars)
*Elofsonia baltica (Hirschmann)

The ostracod species reflect the provenance, being a mixture of phytal and benthic, sediment-dwelling species (marked by *); the presence of L. lacertosa and E. baltica, usually associated with brackish environments, may indicate some permanent lowering of the salinity at this site due to freshwater seepage.

STOP R2 Bell Bay, NW Great Cumbrae Island. Grid ref. NS 163 577. High pool with mainly green filamentous algae (including Cladophora). Locality shown in Figs 1, 5. Ten species were recorded live (see Plates 1, 2), as follows:

Hirschmannia viridis (O.F. Müller)(adults)
Xestoleberis aurantia (Baird)
Semicytherura nigrescens (Baird)
Callistocythere badia (Norman)
Hemicythere villosa (Sars)
Hemicytherura cellulosa (Norman)
Paradoxostoma variabile (Baird)
Paradoxostoma hibernicum Brady
Paradoxostoma trieri Horne & Whittaker
Cytherois pusilla Sars

STOP R3 White Bay, N Great Cumbrae Island. Grid ref. NS 179 593. A mixture of Corallina, Cladophora, etc. and sediment, taken at mid High Water. Locality shown in Figs 1, 5. Six species were recorded live (see Plates 1, 2), as follows:

Hirschmannia viridis (O.F. Müller)(adults)
Xestoleberis aurantia (Baird)

Semicytherura nigrescens (Baird)
Hemicythere villosa (Sars)
Paradoxostoma variabile (Baird)
Cytherois pusilla Sars

STOP R4 Lion Rock, SE Great Cumbrae Island. Grid ref. NS 180 548 (Figs 1, 5). Mainly brown and red algae with some Cladophora at Low Water. Whereas STOPS R1-R3 are pools situated on a rock platform which become isolated from the sea with the falling tide, STOP R4 and for that matter most of the SE coast of Great Cumbrae Island, has a very steeply shelving shore. The turbulence of the water was probably the main cause for the small ostracod populations, only two species being recorded:

Cythere lutea O.F. Müller
Semicytherura nigrescens (Baird)

STOP R5 Kilchattan Bay, Isle of Bute. Sand flats at centre of bay, taken at Low Water. Brown, green and red filamentous algae and sand (stabilized by tube-forming worms). Grid ref. NS 104 555. Locality shown in Fig. 1. Three species were rcorded live:

Hemicythere villosa (Sars)
Hirschmannia viridis (O.F. Müller)(adults)
Leptocythere baltica Klie

The first two named species were probably associated with the algae but L. baltica is known to be a sand-dwelling, marine form.

STOP R6 Kilchattan, Isle of Bute. At the end of the road, south end of village. Sublittoral laminarian algae (holdfasts) at Low Water with various matted red, green and brown algae. Grid. ref. NS 106 546. Locality shown of Fig. 1. A very rich fauna, referable to eleven species, was recorded:

Cythere lutea O.F. Müller
Hemicythere villosa (Sars)
Loxoconcha rhomboidea (Fischer)
Hirschmannia viridis (O.F. Müller)(adults)
Xestoleberis aurantia (Baird)
Hemicytherura cellulosa (Norman)
Semicytherura nigrescens (Baird)
Paradoxostoma variabile (Baird)
Paradoxostoma bradyi Sars
Paradoxostoma pulchellum Sars
Paradoxostoma trieri Horne & Whittaker

STOP R7 Balnakailly Bay, Isle of Bute. Grid ref. NS 022 744. Locality shown in Fig. 1. Taken at Low Water in centre of bay on sand flats. Fucus spp., some green algae and sediment from mussel-bed. Three species, all sediment-dwelling forms were recorded:

Leptocythere baltica Klie
Leptocythere psammophila Guillaume
Leptocythere lacertosa (Hirschmann)

The first-named species has a more truly marine distribution than the latter two, which are usually associated with reduced salinities. Some degree of dilution, due to a stream issuing into the bay near this site, may be responsible. The lack of phytal ostracods reflects the unsuitability of Fucus as a primary habitat.

Fig. 5 Map of Great Cumbrae Island, showing the location of STOPS R1-R4 (stars) and Quaternary raised beach STOP Q1 (triangle). The circles represent sites listed in Robertson (1875).

Fig. 5

1km
White Bay
R3
Tormont End
Ferry from LARGS
Skate Point
Little Skate Bay
Gavin's Glen
Old Quarries
Portnye
Down Craig
Boat Harbour
Horse Hill
R2
Bell Bay
GREAT CUMBRAE ISLAND
(Buteshire)
Figgatoch
Tonnel Hill
Bell Craig
Fairhaven
Quarries
Ballochmartin
Glad Stone
Finlay Bay
Fintrawax Plantation
Golf Course
Sheriff's Common
Barrel Hill
Strathing Hone
Gray Craigs
Clashfarland Point
Craigengour
CUMBRAE
Ballikellet
Gourock Hill
Ballykellet (Site of)
Hospl
Breakough
Club House
Golf Course
Upper Kirkton
Cemy
Davy's Rock
Butter Lump
MILLPORT
CATH
School
Church (Site of)
Cemy
Mid Kirkton
Nether Kirkton
Aird Hill
Kames Bay
New Town
Lion Rock
R4
Bessy's Port
The Eileans
Craigengour Hill
KEPPEL PIER
Marine Station
The Leug
The Spoig
Port Lay
Millport Bay
Farland Point
The Perch
R1
Q1
Raised Beach
Nuplair Rock
Nuplair Point
Portachur Point
FAIRLIE ROADS
THE TAN
Sheanawally Point
Muggie Rock
Gull Rock
1
2
3
4
5
6
7
8
9
10
11
12
13
14

STOP R8 Creggans, east shore of Loch Fyne (about 15km from head of loch). Grid ref. NN 086 020. Locality shown on Fig. 1. Fucus vesiculosus holdfasts (with epiphytes), Enteromorpha and sand. This was the best of several collections taken in the upper part of Loch Fyne. The poor faunas encountered could reflect a more "restricted" environment so far from the "open sea" or be merely the result of temporary seasonal factors. Three species were recorded live:

Elofsonia baltica (Hirschmann)
Leptocythere baltica Klie
Leptocythere psammophila Guillaume

STOP R9 Succoth, head of Loch Fyne (opposite Arrochar). Grid ref. NN 195 049. Locality shown on Fig. 1. Composite sample of mud, green algae (filamentous) and holdfasts and epiphytes of Fucus vesiculosus taken at Low Water. The salinity at the head of this 25km-long sea-loch or fjord is not known but the presence of the alga, F. vesiculosus, would indicate that it is unlikely to be below 25-30°/oo. Four species were recorded live:

Elofsonia baltica (Hirshmann)
Leptocythere baltica Klie
Leptocythere psammophila Guillaume
Leptocythere lacertosa (Hirschmann)

STOP R10 Between Ardrossan and Seamill, by Seaview Hotel. Grid ref. NS 210 454. Locality shown on Fig. 1. Extensive rock platforms giving large rock pools. Two pools were samples, the first was a low pool, taken at Low Water within the sublittoral zone. The sample consisted of Laminarian holdfasts and various red and brown algae with entrapped sand. This low pool had five ostracod species living in it:

Cythere lutea O.F. Müller
Hemicythere villosa (Sars)
Hemicytherura cellulosa (Norman)
Semicytherura nigrescens (Baird)
Paradoxostoma variabile (Baird)

In the second pool, high up the beach, the sample consisted of red, brown and green filamentous algae. Six species were recorded live:

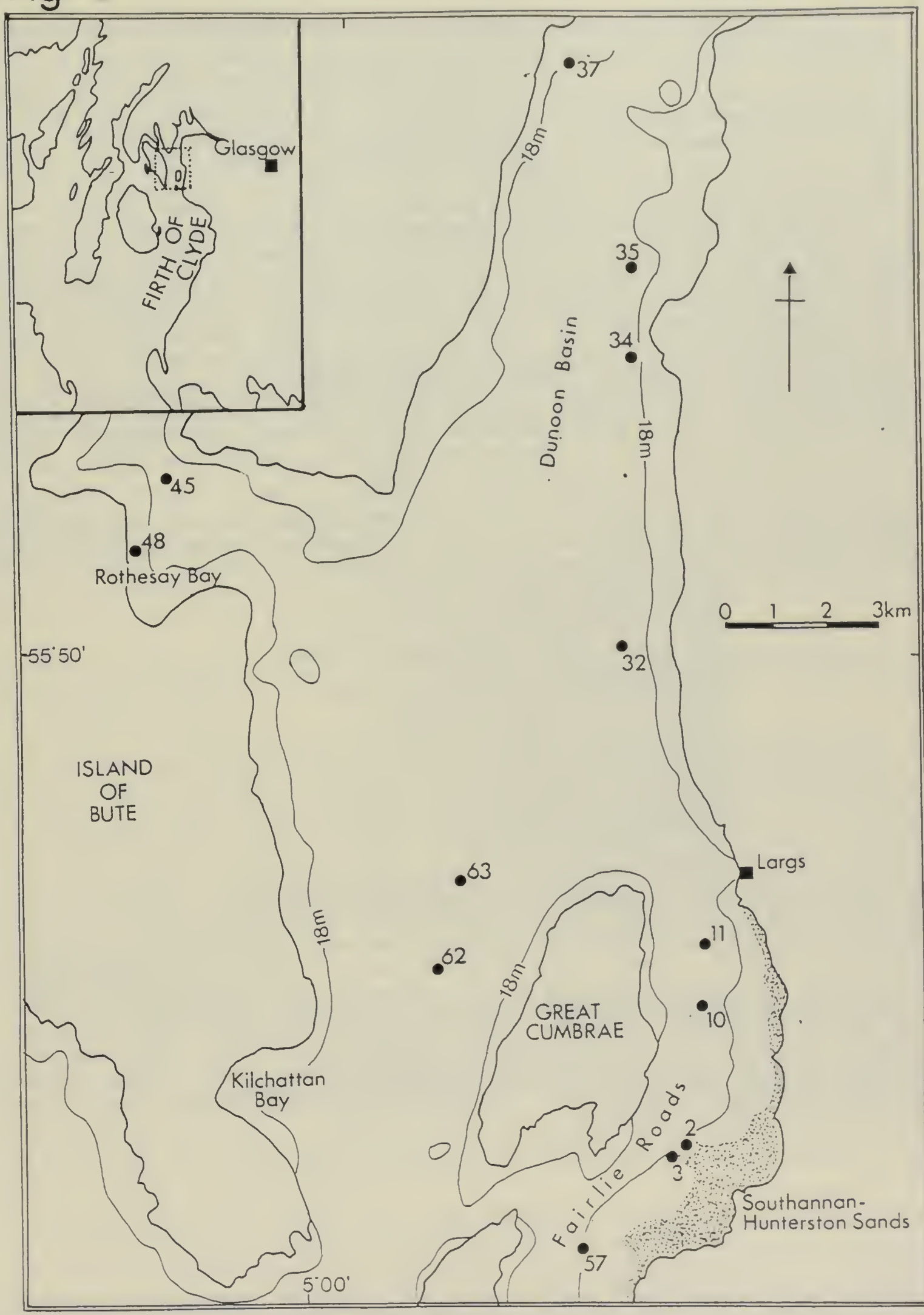
Cythere lutea O.F. Müller
Hemicythere villosa (Sars)
Hirschmannia viridis (O.F. Müller)(adults)
Xestoleberis aurantia (Baird)
Semicytherura nigrescens (Baird)
Paradoxostoma variabile (Baird)

It is interesting to note that X. aurantia and H. viridis were only found in the high pool and H. cellulosa occurred only in the low pool. It might be interesting to sample a detailed transect here to see if there is real vertical variation in the phytal ostracod distribution.

Fig. 6 Firth of Clyde - deeper water sites. Samples and sample numbers are from the survey of Dr K.C. Keen. Some of the localities around Cumbrae can be sampled during cruises on the RV 'APLYSIA'.

These samples, together with others collected by Dr J.E. Robinson at many of the sites favoured by Robertson and his friends (Fig. 5), formed the source material for my review on p. 14.

Fig. 6


Glasgow
FIRTH OF CLYDE
37
18m
35
34
Dunoon Basin
18m
45
48
Rothesay Bay
0 1 2 3km
55°50'
32
ISLAND OF BUTE
63
Largs
18m
62
11
GREAT CUMBRAE
18m
10
Kilchattan Bay
2
3
Fairlie Roads
Southannan-Hunterston Sands
57
5°00'

DEEPER WATER SAMPLES.

It would be unwise to devote a great deal of space to a detailed discussion of the distribution of the deeper water (10–100m) species of the Firth of Clyde. All are figured in Plates 3–6, but with the exception of Leptocythere tenera (Brady)(Pl. 4, fig. 2), none was found alive in the present surveys (Figs 5, 6). Neither Keen's nor Robinson's surveys used underwater divers and sophisticated benthic sledges, which are needed to recover living material even in these sort of depths. The various types of grab and dredge which will be at our disposal on the RV 'APLYSIA', usually produce little in the way of live ostracods. You will, however, recover rich and well preserved material and it is clear, from our studies of the British ostracod faunas in general (Athersuch et al., in press), that all the species listed and figured herein actually do live in the area and are not derived from Quaternary deposits. As a general rule, the shallower the sample the more likely the possibility that dead valves and carapaces of littoral and sublittoral phytal species will be encountered. Significantly, several species, notably Heterocythereis albomaculata (Baird) and Aurila convexa (Baird) were met with in large numbers, species which were never recovered alive in the May 1987 fieldwork; it is hoped these will be collected in our August sampling, as many shallow phytal species are distinctly seasonal in their distribution.

Of the rest, what can be made of their distribution? Almost all samples examined within the depth range (10–100m) contained an almost ubiquitous fauna characterized by: Leptocythere pellucida (Baird)
Leptocythere tenera (Brady)
Sarsicytheridea bradii (Norman)
Sarsicytheridea punctillata (Brady)
Krithe praetexta (Sars)
Robertsonites tuberculatus (Sars)
Palmoconcha laevata (Norman)
Palmoconcha guttata (Norman)
Elofsonella concinna (Jones)
Pterygocythereis jonesii (Baird)
Bonnyannella robertsoni (Brady)
Eucythere argus (Sars)
Cytheropteron spp.
Semicytherura spp. (deepwater forms)
This distribution may reflect the dominant muddy substrate of most of the survey area (Fig. 3). It is interesting to report that the sandflats of Southannan and Hunterston (Fig. 6) have yielded the following - Leptocythere macallana (Brady & Robertson), Semicytherura sella (Sars), Urocythereis britannica Athersuch, and Pontocythere elongata (Brady) - without some of the other species listed above, and it would therefore seem that substrate is the main environmental control in this case. It is hoped the 'APLYSIA' can visit a sandy and a muddy area so that the participants of the excursion can put this hypothesis to the test for themselves.

-oOo-

SOME GENERAL NOTES ON THE ECOLOGY OF BRITISH RECENT COASTAL OSTRACODA.

Many physical and chemical factors influence the distribution of ostracod species: salinity, temperature, pH, oxygen concentration, depth, substrate and food supply are considered significant.

Apart from samples taken at the head of several seas lochs and which contain brackish species (STOP 9), all other localities sampled during the present excursion are fully marine (30-33°/oo)(see Fig. 1).

Water temperature is probably the main control in the geographic distribution of ostracods, just as salinity is the main control in their environmental distribution. A number of species found around the shores of the British Isles are living close to the northern limits of their distribution; characteristic of warmer water (many also occur in the Mediterranean). Others, which prefer colder waters and live near the southern limits of their distribution in British waters include Acanthocythereis dunelmensis (Norman), Robertsonites tuberculatus (Sars), Elofsonella concinna (Jones), Semicytherura undata (Sars) and Palmenella limicola (Norman); many of them also live in the Arctic. In the Quaternary deposits of Northern Britain many more Arctic species are found (see pp. 17-18) but which no longer live here.

Variation in the pH and O_2 content of the water are minor and of little significance in British coastal waters, except in the case of intertidal rock-pools and salt-marsh pools, where isolation from the main water body at low water may lead to marked fluctuations in the physico-chemical parameters. This results in a reduction in the number of species found in higher level pools compared to those lower down the shore.

Depth, in itself, is relatively unimportant and its influence lies in its effects on other factors; water temperature, for example, generally decreases with increasing depth.

The types of substrate inhabited by benthonic marine and brackish-water ostracods can be broadly divided into two categories, plants and sediments. Many, but not all British coastal ostracod species will be found predominantly (but not exclusively) associated with one or other of these types of substrate. Those without particular preference, and which are likely to be found in sediment as in algal samples, include Cythere lutea O.F. Müller, Hemicythere villosa (Sars), species of Aurila, Loxoconcha, Elofsonia, Semicytherura and Cytherois, although it is hard to be certain that such ostracods retrieved from sediment samples may not have been "grazing" on mats of filamentous algae and algal debris on the sediment surface.

Some species are found mainly on sedimentary substrates such as sand and mud, where they either crawl on the sediment surface or burrow to depths of a few centimetres: they include Elofsonella concinna (Jones), Urocythereis britannica Athersuch, species of Eucythere, Leptocythere, Cytheropteron, Palmoconcha and all the Trachyleberididae and Cytherideidae. Many of these species will be collected by you from grab samples on the R.V. 'APLYSIA' around Cumbrae and the Firth of Clyde, but very few of them will be alive due to the crudeness of our sampling methods in deeper water.

Predominantly phytal species, living amongst the fronds or holdfasts of marine algae are much easier to collect and will form the main source of our collections in the Firth of Clyde area. Such species include Propontocypris spp., Heterocythereis albomaculata (Baird) and species of Callistocythere, Hemicytherura, Xestoleberis and Paradoxostoma. The relationship between ostracods and algae has been admirably reveiwed by Whatley & Wall (1975). It appears to be the morphological type of plant rather than the actual species which is of fundamental

importance. An illustrated Key to the more common marine algae of Britain is given on pp.41-47, to which the reader should now refer and during collecting. The richest ostracod faunas are usually obtained from densely interwoven, tufted or filamentous growths of green algae such as Cladophora (p. 47), and red algae such as Ceramium, Polysiphonia (p. 45) and Corallina (calcareous alga) (p. 46). Other important factors, such as amount of trapped sediment, available living space and shelter, are directly related to the overall morphology of the plant. Those with broad, flat fronds like the brown algae Fucus and Ascophyllum (p. 42), rarely support a good ostracod fauna unless they have a dense growth of epiphytes. Laminaria holdfasts (p. 43) form a special kind of habitat with a large amount of trapped sediment and often considerable growth of epiphytic algae. Furthermore, those algae whose morphology enables them to retain a lot of moisture during periods of exposure in the intertidal zone will offer a more hospitable environment to ostracods and other meiofauna. In the sublittoral, provision of shelter and resistance to dessication are of reduced importance, and faunas are consequently found on a wider variety of algae.

A "phytal" or "phytophylous" ostracod fauna often contains a mixture of true phytal species and sediment-dwelling species, not only because algae trap sediments, but also due to ostracods straying from their preferred habitats.

Sediment-dwelling ostracods may similarly show a preference for a particular type of sediment: Leptocythere psammophila Guillaume, as its name suggests, is usually found on sandy substrates in the estuarine environment; L. macallana (Brady & Robertson), likewise in the more marine environment; while L. porcellanea (Brady)(until recently referred to by most authors as L. ilyophila (Hirschmann)) is most commonly associated with mud.

Food supply is clearly an important influence on distribution, but information on the feeding habits of benthic ostracods is limited to a few observations. Most marine and brackish cytheraceans are assumed to be scavengers, feeding on dead plant or animal debris, or herbivores feeding on diatoms. Diatom frustules can often be observed in the stomach contents of certain genera (e.g. Loxoconcha). Others may be considered "silt-eaters" ingesting fine sediments and obtaining nourishment from the small bacteria and algae coating the grains; Semicytherura sella (Sars), for example, has been found with its stomach full of fine quartz grains. The genus Paradoxostoma with its highly specialised mouthparts, evidently feeds by piercing and sucking, though whether it prefers plant or animal tissue remains a subject for debate (Horne & Whittaker, 1985); since this adaptation is also found in related genera which are commensal, a carniverous life-style perhaps is more likely.

-cOo-

QUATERNARY OSTRACODA OF THE FIRTH OF CLYDE

THE DEVENSIAN (WEICHSELIAN) LATEGLACIAL SEA AND ITS DEPOSITS - THE CLYDE BEDS.

The major effects of the period of deglaciation that followed the Late Devensian (Late Weichselian of Continental usage) ice maximum in the Clyde Sea area were twofold: uncovering of an ice-modified surface that differed greatly from that prior to glaciation, and flooding of part of that surface by marine waters shortly after the melting of the ice. Marine incursion may have begun at about 14,000 BP, and by 13,500 BP the whole of the Firth of Clyde area may have been clear of ice and have been flooded by the sea. The maximum extent of this Devensian Lateglacial sea is shown in Fig. 7. Offshore sediments that accumulated in this sea have been termed the CLYDE BEDS and range in age from c.13,150 BP to c.10,000 BP, the beginning of the Holocene Epoch. The Clyde Beds occur at numerous localities at levels between a few metres below Ordnance Datum (O.D.) and 37m O.D., in places they exceed 20m in thickness.

As early as 1874, Brady, Crosskey & Robertson demonstrated that the oldest fossil ostracods from the Clyde Beds from the Paisley area (Fig. 7) were associated with what they termed Arctic-Sea-water temperatures. Such species as Rabilimis mirabilis (Brady), Krithe glacialis Brady, Crosskey & Robertson and Cytheropteron montrosiense Brady, Crosskey & Robertson, for instance, which today live in the Barents Sea-Greenland area, relate to deposits accumulated immediately after deglaciation of the Firth of Clyde, in waters with temperatures close to freezing and turbid with suspended sediment. Later deposits indicate somewhat warmer water but still with species that no longer live in Britain and which are distinctly "Northern" in aspect.

The most recent work published on the ostracods of the Clyde Beds is based on localities at Ardoyne (Fig. 7)(Graham & Wilkinson, 1978; Peacock et al., 1978). Several species, notably Cluthia cluthae (Brady, Crosskey & Robertson), Barentsovia angulata (Sars), Cytheropteron montrosiense Brady, Crosskey & Robertson, Hemicytherura clathrata (Sars), Heterocyprideis sorbyana (Jones), Acanthocythereis sp. and Roundstonia globulifera (Brady), no longer live in British waters and must be taken as substantiating the cold-water nature of the deposit.

Of the many Clyde Bed localities mentioned by Brady, Crosskey & Robertson (1874) the one we can visit on this excursion is at the north end of the Isle of Bute at Balnakailly Bay.

STOP Q2 Clyde Beds, Late Devensian. Balnakailly Bay, grid ref. NS 022 744. Locality shown on Fig. 1.

Mentioned by Brady, Crosskey & Robertson (1874: 57) and in rather more detail in Crosskey & Robertson (1875) where it is referred to as Balnakaile or Balnakeaile. It occurs in the west bank of a small stream issuing into the Bay and consists of at least 60cm of clay overlain by 25cm of gravelly clay with the mollusc Mya in life position. It is recommended that both the shell bed and clay be sampled. From a sample taken from the shell bed I recovered 15 species of Ostracoda, as follows:

Elofsonella concinna (Jones)
Sarsicytheridea bradii (Norman)
Sarsicytheridea punctillata (Brady)
Barentsovia angulata (Sars)
Hemicythere villosa (Sars)
Acanthocythereis sp. (see p. 24)
Palmoconcha laevata (Norman)
Cythere lutea O.F. Müller

Semicytherura undata (Sars)
Semicytherura nigrescens (Baird)
Palmenella limicola (Norman)
Leptocythere pellucida (Baird)
Cytheropteron nodosum Brady
Cytheropteron latissimum (Norman)
Cytheropteron montrosiense Brady, Crosskey & Robertson

Of these Barentsovia angulata, Acanthocythereis sp. (see p. 24) and Cytheropteron montrosiense do not, in my experience, live in British waters today.

Another very fossiliferous locality on Bute which used to be exposed, is on the NW side of Kilchattan Bay (Brady, Crosskey & Robertson, 1874: 53-56). It can no longer be seen which is unfortunate as the figured specimens of Cluthia cluthae (Brady, Crosskey & Robertson, 1874; Pl. 13, figs 16, 17) came from here.

A sample of the Clyde Beds from Rhu (Fig. 7), on the north side of the Clyde, will be distributed to members of this Excursion.

Detailed work by Peacock (1981), in relation to the distribution of species of Littorina and other molluscs in the Lateglacial Clyde Sea, suggests that conditions were subarctic between c.12,500 and 12,000 BP, and temperatures in the Clyde Sea between c.13,000 and 11,000 BP may have been 3°C lower than at present (compare with Fig. 4).

Between c.11,000 and 10,000 BP there occurred a further cooling and re-advance of the ice, this is the LOCH LOMOND STADIAL. Remnants of former sea-cliffs and an associated intertidal rock platform at levels up to +11m O.D. which occur discontinuously along the shores of the Firth of Clyde - you will see them particularly around the shores of the islands of Bute and Cumbrae - are considered, at least in part, the products of severe shore erosion during the Loch Lomond Stadial, by combination of frost shattering and marine erosion.

THE FLANDRIAN (HOLOCENE) POSTGLACIAL EPOCH.

Major changes in the physical environment of the Clyde Sea area occurred during the last 10,000 years, especially in the position of the shoreline; a rapid global rise in sea level between c.8,400 and 5,500 BP caused a marine transgression, continued local rise of land thereafter resulted in marine regression and formation of the present shoreline.

Extensive Late Flandrian deposits on the Big Bend of the River Irvine, at Shewalton, near Irvine (see Fig. 7) were visited by the author during the fieldwork for this Guidebook. These deposits, of sands, clays, lithothamnion-coated gravels and abundant beds of molluscs, up to 12m thick, were deposited in a large embayment of the sea between Ardrossan and Troon (Fig. 7) when the shoreline was located 2km inland from the present shore. These deposits are however difficult of access and will not be visited on this Excursion.

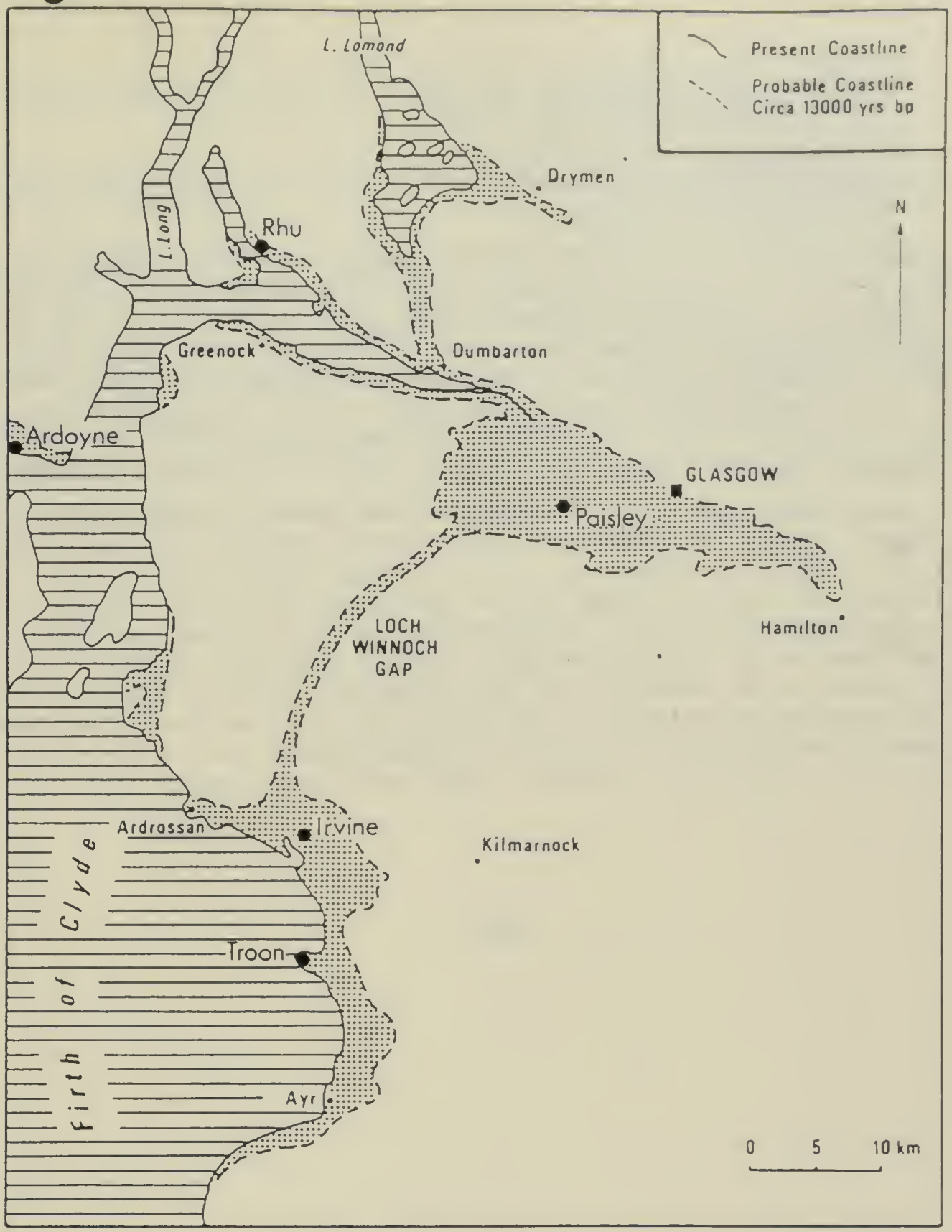
We shall visit a raised beach site in the SW of Great Cumbrae which also dates from Late Flandrian times (c.6,000 BP).

STOP Q1 Raised Beach, Late Flandrian. Eileann na Gourack. Grid ref. NS 150 541. Locality shown in Figs. 1, 5.

It is situated on the rock-cut platform at the top of the modern beach, near to our Recent sampling locality (STOP R1). The exposed sediments are very thin, being made up of about 10cm of greenish clay with a shell bed above, the whole resting on Devonian bedrock.

Fig. 7 Lateglacial coastline of the Firth of Clyde (after Price, 1983).

Fig. 7



From a composite sample some 19 species were recovered:

Pontocypris mytiloides (Norman)
Aurila convexa (Baird)
Hemicythere villosa (Sars)
Heterocythereis albomaculata (Baird)
Barentsovia angulata (Sars)
Sarsicytheridea bradii (Norman)
Hirschmannia viridis (O.F. Müller)
Loxoconcha rhomboidea (Fischer)
Bonnyannella robertsoni (Brady)
Leptocythere pellucida (Baird)
Leptocythere baltica Klie
Leptocythere tenera (Brady)
Xestoleberis aurantia (Baird)

Hemicytherura cellulosa (Norman)
Semicytherura nigrescens (Baird)
Semicytherura acuticostata (Sars)
Semicytherura angulata (Brady)
Semicytherura sella (Sars)
Paradoxostoma ensiforme gr.

This fauna, a mixed littoral/sublittoral-inner shelf assemblage of phytal and benthic species, is near-identical to what might live around the shores of Cumbrae today (see Chapter on the Recent Ostracoda, pp. 9-14). The occurrence of Barentsovia angulata in these deposits is the exception. Although found as dead valves in Recent assemblages in the Firth of Clyde I have not seen undoubted living individuals from the British Isles at the present day. Because of its modern distribution (see above), this may indicate that even as late as 6,000 years ago the water temperatures were still not as warm as today.

In the last century the actual outcrop of the raised beaches of Cumbrae was more extensive; now it is difficult to see actual exposure because of buildings, concrete, etc. Millport itself is built upon the raised beach, as is the road around the island. You will also notice the former sea-cliffs behind. Brady, Crosskey & Robertson (1874: 52, 53) describe an outcrop found during excavations for a water tank at the College, Millport, while Robertson himself (1878) describes several sites around Kames Bay, Millport and lists (op.cit.: 199) 19 species of Ostracoda from them; a near-identical fauna to that given above.

For further reading about the Firth of Clyde during the Quaternary you are referred to Price (1983) and Jardine (1986), both basic references.

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LIST OF RECENT SPECIES WITH TYPE-LOCALITIES FROM THE FIRTH OF CLYDE.

Bythocythere robinsoni Athersuch, Horne & Whittaker, 1985. Rothesay Bay, Isle of Bute.

Celtia quadridentata (Baird, 1850). Syntypes from several localities, including the Isle of Arran.

Cytheropteron inornatum Brady & Robertson, 1872. Rothesay Bay, Isle of Bute.

Hemicythere rubida (Brady, 1868). Clackland Point, Isle of Arran.

Hemicytherura cellulosa (Norman, 1865). Lamlash Bay, Isle of Arran.

Pterygocythereis jonesii (Baird, 1850). Kilchattan Bay, Isle of Bute.

Pontocypris mytiloides (Norman, 1862). Lamlash Bay, Isle of Arran.

-oOo-

DAVID ROBERTSON 1806-1896

David was born in Glasgow of poor parents, his father dying a few weeks after his birth. He was sent to school at the age of 7 to learn to read but after a year his mother, forced to bring up the family of three young children on her own, had to take him away and send him out to work on an Ayshire farm. Working variously as a farmworker, weaver and quarryman until the age of 24, he then decided to try to improve himself and therefore entered Anderson's College, Glasgow as a medical student. In the meantime he had taught himself writing, arithmetic and book-keeping. At college he somehow afforded his fees, partly out of part-time work and partly out of tutoring the sons of his landlord. Just before he was due to sit his final examinations he became engaged to one of the daughters of a Mr Douglas, a dyer and renovator for whom he had worked. He must have decided that there was little prospect of being able to support a wife and family as a young doctor as he curtailed his studies, bought a china shop (which his wife was to manage) and went to work full-time in the dye works.

Mr Douglas and his family frequented Millport, Cumbrae for their holidays and David Robertson often went with them; it was these visits that first generated his life-long interest in marine life. The china business prospered but his wife died in 1837. Si.. years later, however, he married again and the new Mrs Hannah Robertson, twenty years his junior and a very enthusiastic personality, quickly became as much interested in marine life as he, making the Foraminifera her special subject.

In 1851 the Glasgow Natural History Society was founded and Robertson then and subsequently took a leading part in its activities, publishing many papers in its Transactions over the years. In the late 1850's both he and his wife had been seriously ill. Now a wealthy man he therefore decided to retire early and concentrate on what was now his first love. He leased a house, 'Fernbank', in Kames Bay, Millport and although they did not at first live there permanently, they spent every summer there and his time was given wholly to marine biology. His main interests were in dredging and the study of the Ostracoda. Through this work he became friendly with fellow ostracod workers such as George Stewardson Brady and Rev. Alfred Merle Norman. In the Glasgow scientific circle he was also interested in glacial geology in company with his friends, James Smith of Jordanhill and Rev. Henry Crosskey, then a Unitarian minister in Glasgow. With Brady and Crosskey, Robertson wrote in 1874 the classic Monograph of the Post-Tertiary Entomostraca of Scotland... which remains one of the few overall accounts of Pleistocene ostracod faunas of the British Isles. He travelled a good deal, often with Brady on dredging expeditions and even went to Norway to visit the Sars', father and son. His enthusiasm was infectious and he impressed all who met him. Later in life he met Dr (later Sir) John Murray (of Challenger Expedition fame) and it was because of their friendship, the presence of David Robertson in Millport and the world-wide reputation he had attracted, that decided Murray to settle 'The Ark', his floating marine station there.

Robertson had for many years cherished the idea of a permanent Marine Station on Cumbrae and in 1894, with a group of business and professional men from Glasgow who had like interests in marine science, he formed a committee to build one. On August 17th, 1896 Robertson cut the first sod but died 3 months later at the age of 90. In 1897 the Millport Marine Station was formally opened, the ceremony being performed by Sir John Murray. A Building Fund and later, a Memorial Fund for Robertson, provided nearly enough to pay for the building and the Marquess of Bute leased the ground for a nominal rent. 'The Ark' and most of her contents were presented to the Station while at the same time David

Robertson's collections were presented by his widow and the Robertson Museum housing them was named in his honour.

Before his death he had two years previously been awarded the honorary degree of Doctor of Laws at Glasgow University. During his later life he had been elected to several learned societies in Europe as well as to the Fellowship of the Linnean Society and the Geological Society in Britain. Fitting tribute to a remarkable man from such humble beginnings.

Those seeking further information on the life of Robertson should try to read Stebbing (1891), 'The Naturalist of Cumbrae'. Some of the above has been gleaned from the history of the Marine Station, Millport (Marshall, 1987) which can be purchased from the Station's bookshop, price £5.

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TAXONOMIC NOTE ON ACANTHOCYTHEREIS DUNELMENSIS (NORMAN).

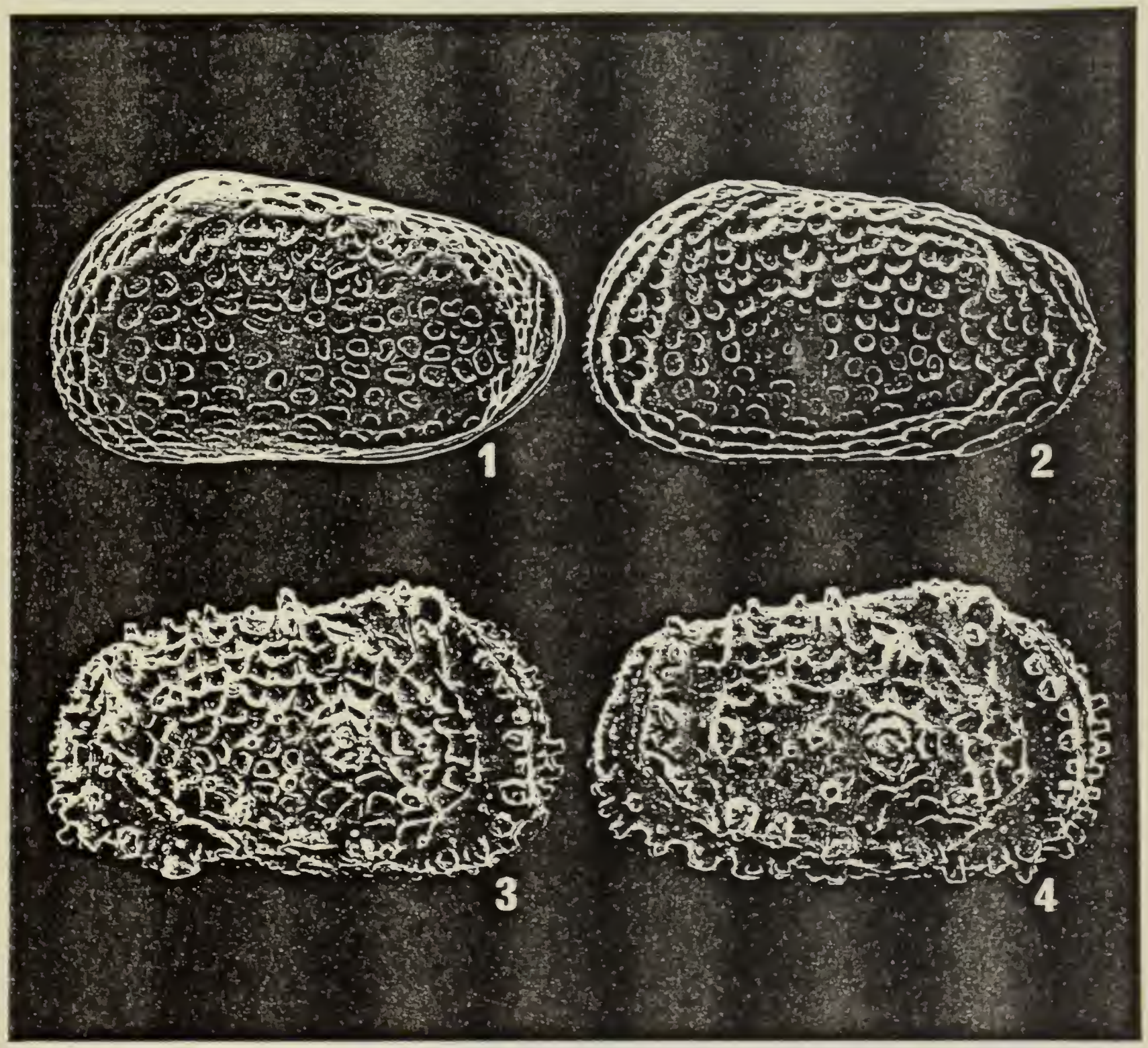
There are clearly two species referred by authors to Acanthocythereis dunelmensis (Norman). The species was founded on a single female specimen by Norman (1865) from off the coast of Durham, NE England (hence the name). The female specimen shown opposite in Fig. 8.3, from the Recent of the Isle of Bute, is undoubtedly conspecific, as indeed are all British Recent records known to me.

Another species, which today appears to live only in more Northern waters, has also been cited as A. dunelmensis by many authors (e.g. Neale & Howe, 1975). In Britain, this latter species is confined to Quaternary deposits and because of its modern distribution must be taken as an indicator of "cold" or "cooler" conditions. Fig. 8.4 illustrates such a specimen, also a female, from the Clyde Beds, Balnakailly Bay, Bute. Both forms apparantly live today in Norway, hence Elofson's (1941) so-called "smaller" and "larger" forms of dunelmensis, but he did not think they were different species. Not only are the male copulatory appendages very different but the carapace morphology is subtly different, once one knows what to look for. The true A. dunelmensis has in both the male and female a broad, non-reticulate rim, posteroventrally, bearing several large clavate spines. In the so-called "dunelmensis", only the male bears posteroventral clavate spines, while the female has a compressed, evenly rounded posteroventral margin bearing only small spines; there are other subtle differences in shape and ornament. More work is required before a name can be assigned to this species and it is merely referred to as Acanthocythereis sp. in this Guidebook.

Figs 8.1, 2 Two Recent ostracods named in honour of David Robertson.
1, Bonnyannella robertsoni (Brady, 1868); a male carapace, left side, x165.
2, Robertsonites tuberculatus (Sars, 1866); a female carapace, left side, x85. Both from The Tan, off Cumbrae.

Fig. 8.3 Acanthocythereis dunelmensis (Norman, 1865) sensu stricto; a female a female right valve, x90. From Kames Bay, Bute; Recent.
Fig. 8.4 Acanthocythereis sp.; a female right valve, x 85. From the Clyde Beds, Balnakailly Bay, Bute; Quaternary, Late Devensian.

FIG. 8



ACKNOWLEDGEMENTS

The writer is indebted to Dr D.J. Horne (City of London Polytechnic) for his generous assistance in the field, providing copies of his drawings from which Plates 1-6 were assembled, and for his advice. Dr M.C. Keen (University of Glasgow) helped to plan the field work, offered generous hospitality in his home and provided samples from his own surveys. Dr J.E. Robinson (University College, London) also made available many samples from the Firth of Clyde area which have also enhanced the chapter on the Recent Ostracoda. Some picking assistance was provided by Dr D.J. Horne and I. J. Slipper (City of London Polytechnic) and the samples were kindly processed by Ms. R. Gent (formerly of the same Institution).

Thanks go to the staff of the Marine Station, Cumbrae, for their help and good offices in planning the itinerary and for agreeing to offer their excellent facilities to our party; in particular these include the Director, Dr J.A. Allen, the Secretary, Mr D.J. Murden, and Dr G. Moore.

All the authorities from which figures have been taken or adapted are cited in the text. The Guidebook would have been the poorer without them.

RECENT OSTRACODA OF THE FIRTH OF CLYDE

PLATES

after Athersuch, Horne & Whittaker (in press).

EXPLANATION OF PLATE 1

LIVING OSTRACODA OF THE LITTORAL OF THE FIRTH OF CLYDE AREA - COLLECTED MAY 24-26TH 1987. DRAWINGS BY DR D.J. HORNE.

Fig. 1 Leptocythere psammophila Guillaume, 1976. 1a, Female LV; 1b, Male LV; 1c, Male RV internal. x80.

Fig. 2 Leptocythere lacertosa (Hischmann, 1912). 2a, Female LV; 2b, Male LV; 2c, Male RV internal. x100.

Fig. 3 Leptocythere baltica Klie, 1929. 3a, Female LV; 3b, Male LV; 3c, Female RV internal. x100.

Fig. 4 Elofsonia baltica (Hirschmann, 1909). 4a, Female carapace, left side; 4b, Male carapace, left side; 4c, Male RV internal. x90.

Fig. 5 Cythere lutea O.F. Müller, 1785. 5a, Female carapace, left side; 5b, Male LV internal. x70.

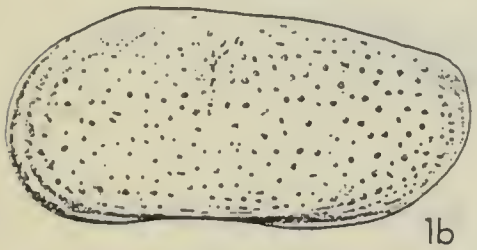
Fig. 6 Hemicythere villosa (Sars, 1866). 6a, Female LV; 6b, Male LV; 6c, Male RV internal. x30.

Fig. 7 Loxoconcha rhomboidea (Fischer, 1855). 7a, Female RV; 7b, Male RV internal. x70.

Fig. 8 Hirschmannia viridis (O.F. Müller, 1785). 8a, Female carapace, left side; 8b, Male carapace, left side; 8c, Male RV internal. x90.

Fig. 9 Semicytherura nigrescens (Baird, 1838). 9a, Female carapace, left side; 9b, Male carapace, left side; 9c, Male LV internal. x110.

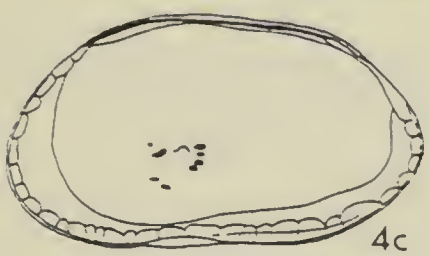
1a


1b

1c

4a

4b


4c

2a

2b

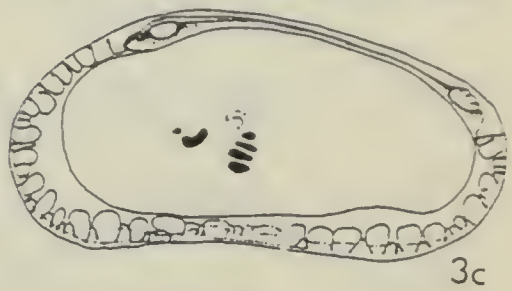
2c

5a

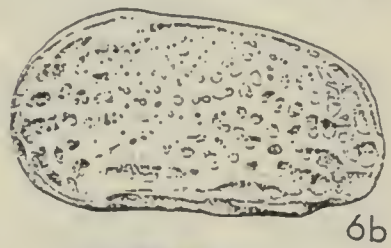
5b

3a

3b


3c

6a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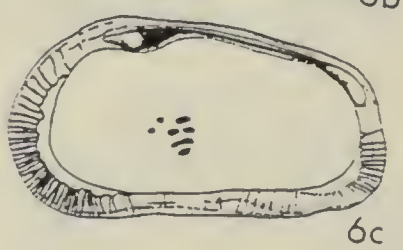
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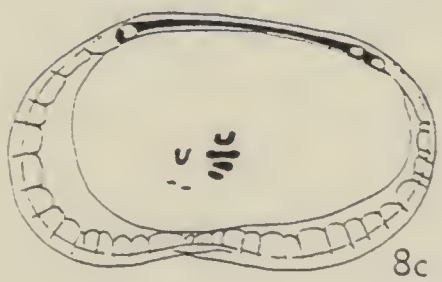
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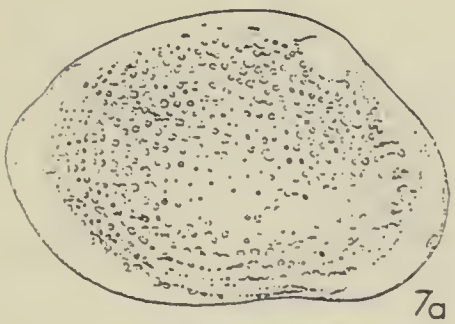
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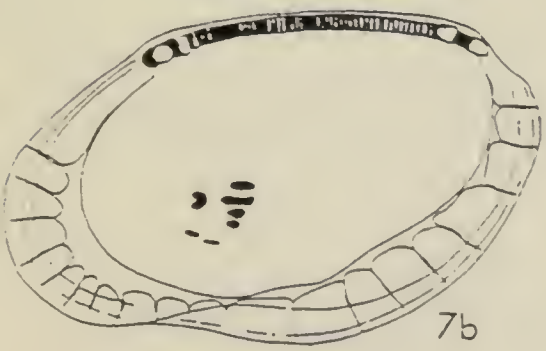

7b

9a

9b

9c

EXPLANATION OF PLATE 2

LIVING OSTRACODA OF THE LITTORAL OF THE FIRTH OF CLYDE AREA - COLLECTED MAY 24-26TH 1987. DRAWINGS BY DR D.J. HORNE.

Fig. 1 Callistocythere badia (Norman, 1862). 1a, Male LV; 1b, Female RV internal. x120.

Fig. 2 Xestoleberis aurantia (Baird, 1838). 1a, Female LV; 1b, Male LV; 1c, Female LV internal. x125.

Fig. 3 Paradoxostoma hibernicum Brady, 1868. 3a, Female LV internal; 3b, Male LV internal. x85.

Fig. 4 Paradoxostoma trieri Horne & Whittaker, 1985. 4a, Female LV internal; 4b, Male LV internal x90.

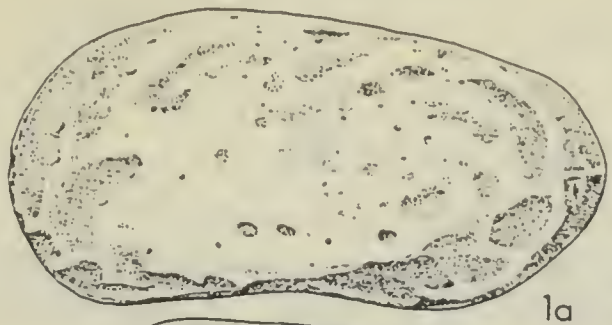
Fig. 5 Paradoxostoma pulchellum Sars, 1866. 5a, Female LV internal; 5b, Male LV internal. x120.

Fig. 6 Paradoxostoma bradyi Sars, 1928. 6a, Female LV internal; 6b, Male LV internal. x80.

Fig. 7 Paradoxostoma variabile (Baird, 1835). 7a, Female LV internal; 7b, Male LV internal. x75.

Fig. 8 Hemicytherura cellulosa (Norman, 1865). 8a, Female LV internal; 8b, Female carapace, left side; 8c, Male LV; 8d, A-1 instar LV. x115.

Fig. 9 Cytherois pusilla Sars, 1928. 9a, Female RV internal; 9b, Male RV internal. x140.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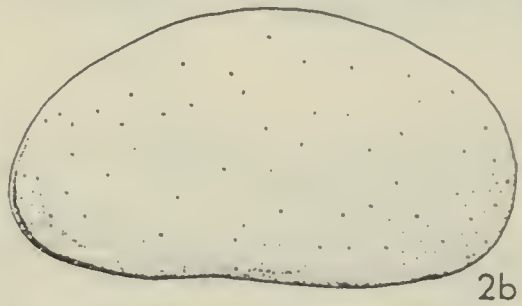
2a

1b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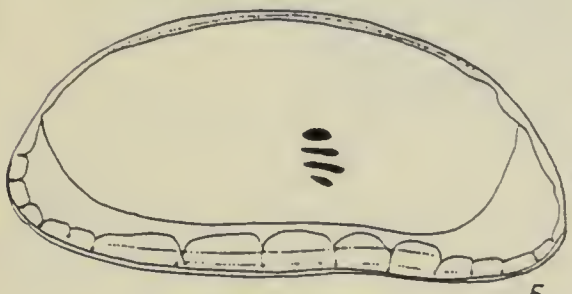
3a

3b

2c

4a

4b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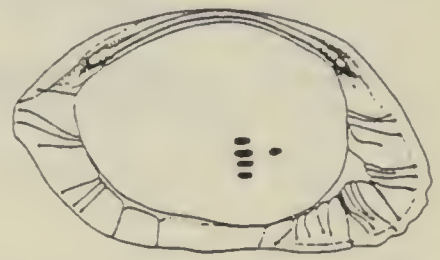
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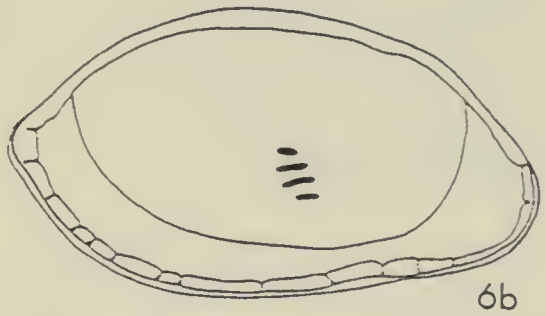
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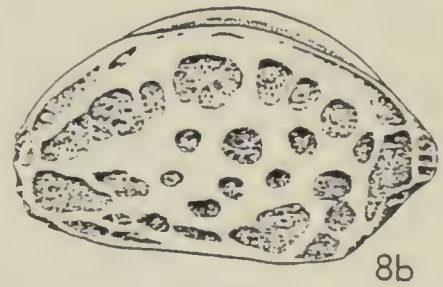
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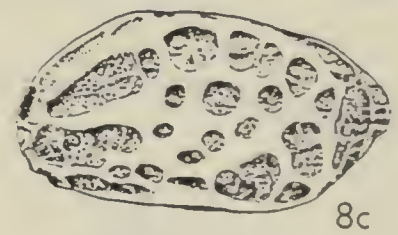
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8d

9a

9b

EXPLANATION OF PLATE 3

RECENT, MAINLY DEEPER WATER (20-100 M), OSTRACODA OF THE FIRTH OF CLYDE AREA - COLLECTED BY DRS J.E. ROBINSON AND M.C. KEEN. ALL WERE DEAD AT THE TIME OF COLLECTION. DRAWINGS BY DR D.J. HORNE.

Fig. 1 Paracypris polita Sars, 1866. Female LV internal. x70.

Fig. 2 Propontocypris trigonella (Sars, 1866). 2a, Female carapace, left side; 2b, Male carapace, left side; 2c, Female LV internal. x 75.

Fig. 3 Pontocypris mytiloides (Norman, 1862). 3a, Female LV; 3b, Female LV internal. x65.

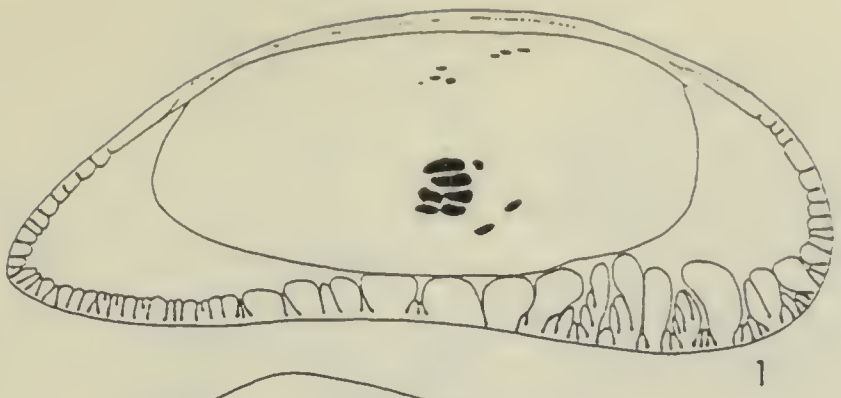
Fig. 4 Palmenella limicola (Norman, 1865). 4a, Male LV; 4b, Female RV internal. x100.

Fig. 5 Eucythere argus (Sars, 1866). 5a, Female LV; 5b, Male LV; 5c, Female LV internal. x90.

Fig. 6 Sarsicytheridea punctillata (Brady, 1865). Male LV. x75.

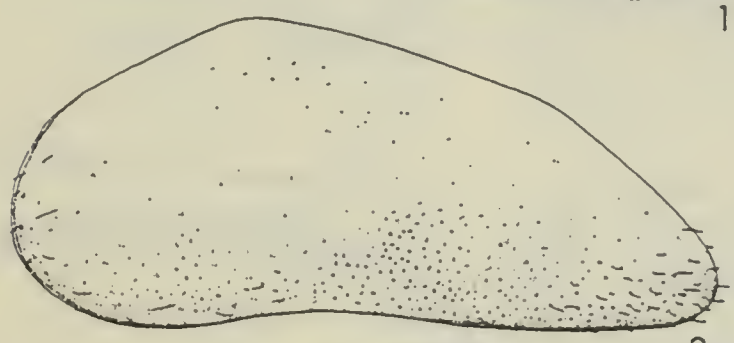
Fig. 7 Sarsicytheridea bradii (Norman, 1865). 7a, Female LV; 7b, Male RV internal. x50.

Fig. 8 Krithe praetexta (Sars, 1866). 8a, Female LV; 8b, Female RV internal. x65.



1

2a



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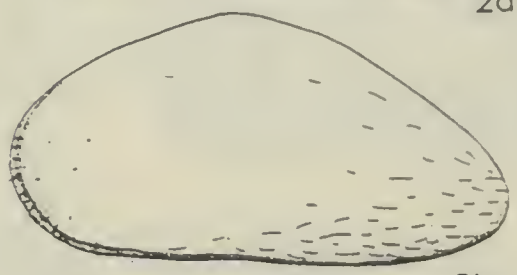


2b

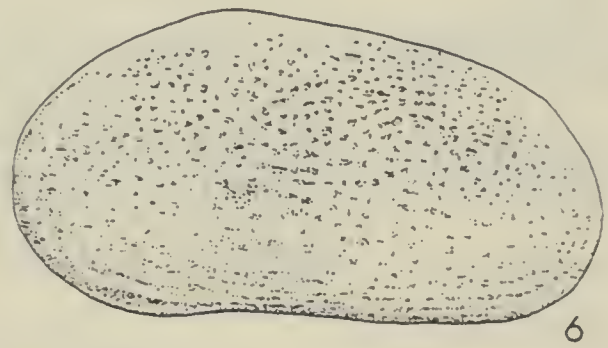
3b

2c

4a

4b

5a



6

5b

7a

7b

5c

8a

8b

EXPLANATION OF PLATE 4

RECENT, MAINLY DEEPER WATER (20-100 M), OSTRACODA OF THE FIRTH OF CLYDE AREA - COLLECTED BY DRS J.E. ROBINSON AND M.C. KEEN. ALL, EXCEPT *LEPTOCYTHERE TENERA*, WERE DEAD AT THE TIME OF COLLECTION. DRAWINGS BY DR D.J. HORNE.

Fig. 1 *Leptocythere pellucida* (Baird, 1850). 1a, Female car pace, right side; 1b, Male carapace, right side; 1c, Female LV internal. x65.

Fig. 2 *Leptocythere tenera* (Brady, 1868). 2a, Female LV; 2b, Male LV; 2c, Female RV internal. x90.

Fig. 3 *Leptocythere macallana* (Brady & Robertson, 1869). 3a, Female LV; 3b, Male LV. x95.

Fig. 4 *Callistocythere littoralis* (G.W. Müller, 1894). Female LV. x95.

Fig. 5 *Pontocythere elongata* (Brady, 1868). 5a, Female LV; 5b, Male RV; 5c, Male RV internal. x60.

Fig. 6 *Acanthocythereis dunelmensis* (Norman, 1865). Female LV. x55.

Fig. 7 *Celtia quadridentata* (Baird, 1850). 7a, Female RV; 7b, Male RV. x70.

Fig. 8 *Carinocythereis carinata* (Roemer, 1838). 8a, Female RV; 8b, Male RV. x40.

Fig. 9 *Carinocythereis whitei* (Baird, 1850). 9a, Female RV; 9b, Male RV. x50.

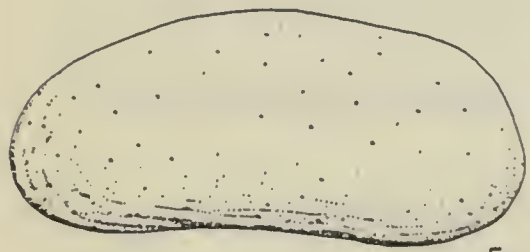
Fig. 10 *Pterygocythereis jonesii* (Baird, 1850). 10a, Female LV; 10b, Male LV. x55.

Fig. 11 *Robertsonites tuberculatus* (Sars, 1866). 11a, Female LV; 11b, Male LV; 11c, Female RV internal. x40.

1a

1b

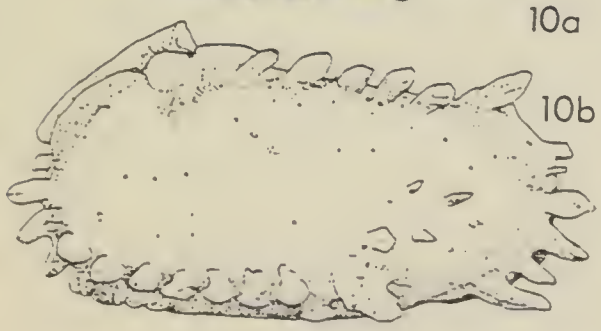
1c


5a

5b

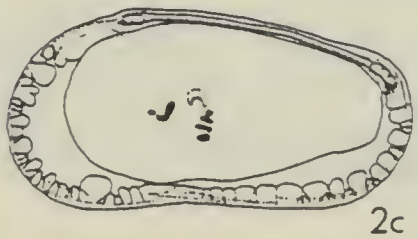
5c

10a


10b

2a

2b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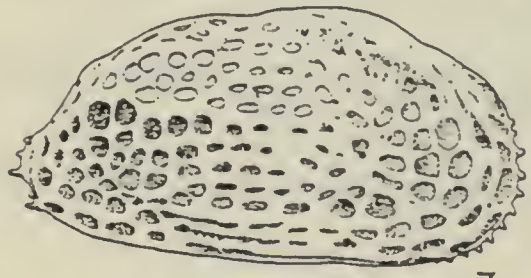
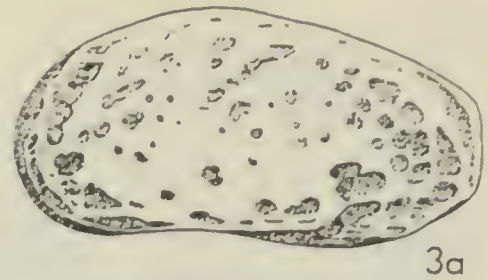

7a

7b

11a

11b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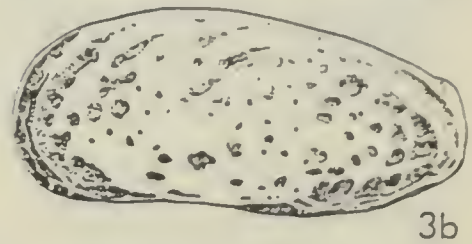

3b

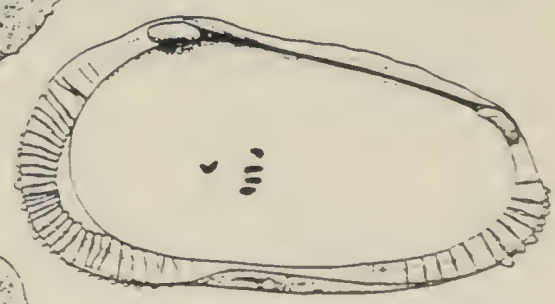
4

8a

8b

9a

9b


11c

EXPLANATION OF PLATE 5

RECENT, MAINLY DEEPER WATER (10–100 M), OSTRACODA OF THE FIRTH OF CLYDE AREA – COLLECTED BY DRS J.E. ROBINSON AND M.C. KEEN. ALL WERE DEAD AT THE TIME OF COLLECTION. DRAWINGS BY DR D.J. HORNE.

Fig. 1 Aurila convexa (Baird, 1850). 1a, Female LV; 1b Female RV; 1c, Female LV internal. x70.

Fig. 2 Elofsonella concinna (Jones, 1857). 2a, Female RV; 2b, Male RV. x55.

Fig. 3 Urocythereis britannica Athersuch, 1977. Male RV. x65.

Fig. 4 Heterocythereis albomaculata (Baird, 1838). 4a, Female LV; 4b, Male LV; 4c, Female RV internal. x55.

Fig. 5 Palmoconcha laevata (Norman, 1865). 5a, Female RV; 5b, Male RV; 5c, Male RV internal. x85.

Fig. 6 Palmoconcha guttata (Norman, 1865). 6a, Female LV; 6b, Male LV. x70.

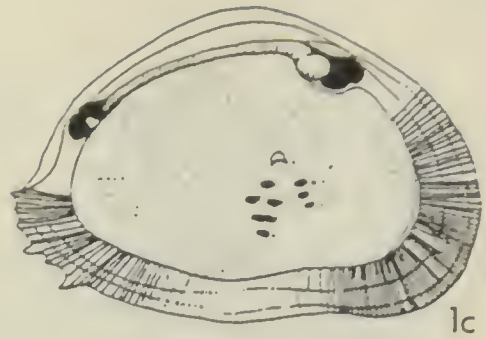
Fig. 7 Bonnyannella robertsoni (Brady, 1868). 7a, Female LV; 7b, Male RV internal. x85.

Fig. 8 Sagmatocythere multifora (Norman, 1865). 8a, Female LV; 8b, Male RV internal. x80.

Fig. 9 Xestoleberis depressa Sars, 1866. 9a, Female LV; 9b, Male LV. x95.

1a

1b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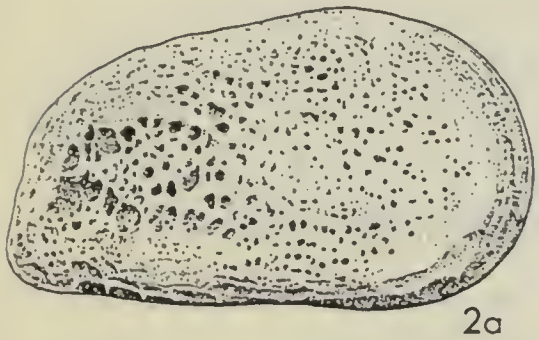
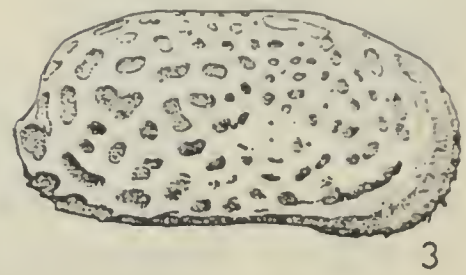

2a

2b


3

4a

4b

4c

5a

5b

5c

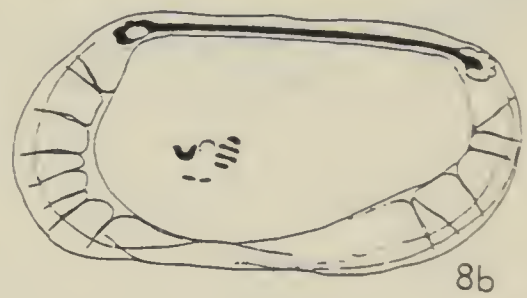
6a

6b

7a

7b

8a


8b

9a

9b

EXPLANATION OF PLATE 6

RECENT, MAINLY DEEPER WATER (10–100 M), OSTRACODA OF THE FIRTH OF CLYDE AREA – COLLECTED BY DRS J.E. ROBINSON AND M.C. KEEN. ALL WERE DEAD AT THE TIME OF COLLECTION. DRAWINGS BY DR D.J. HORNE.

Fig. 1 Semicytherura acuticostata (Sars, 1866). Female LV. x90.

Fig. 2 Semicytherura angulata (Brady, 1868). Female LV. x140.

Fig. 3 *Semicytherura sella (Sars, 1866). 3a, Female carapace, left side; 3b, Male carapace, left side. x100.

Fig. 4 Semicytherura striata (Sars, 1866). Male RV. x145.

Fig. 5 Semicytherura undata (Sars, 1866). Female LV. x80.

Fig. 6 Semicytherura cornuta (Brady, 1868). Male LV. x105.

Fig. 7 Cytheropteron nodosum Brady, 1868. Male carapace, left side. x90.

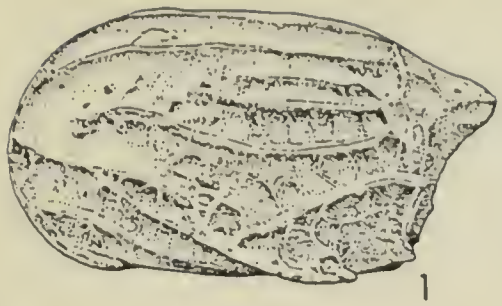
Fig. 8 Cytheropteron latissimum (Norman, 1865). 8a, Female LV; 8b, Male LV; 8c, Female LV internal. x70.

Fig. 9 Paradoxostoma tenuissimum (Norman, 1869). 9a, Female RV internal; 9b, Male RV internal. x70.

Fig. 10 Jonesia acuminata (Sars, 1866). 10a, Female LV internal; 10b, Male LV internal. x50.

Fig. 11 Paradoxostoma angliorum Horne & Whittaker, 1985. 11a, Female LV internal; 11b, Male LV internal. x90.

* S. sella was subsequently found live at Eileann na Gourack, Cumbrae (STOP R1) (see p. 9).

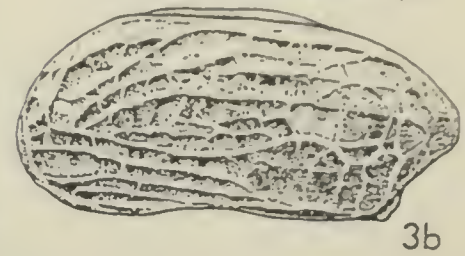

1

2

3a

4

5


3b

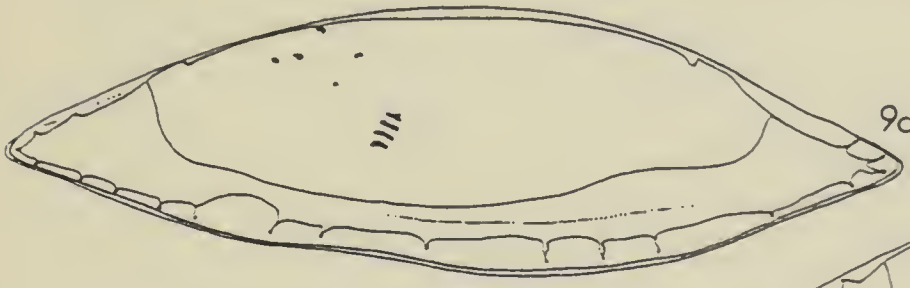
6

7

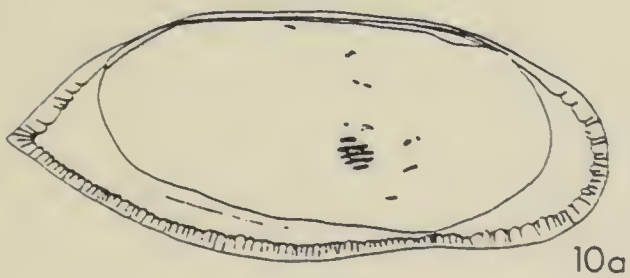
8a

8b

8c


9a

9b


10a

10b

11a

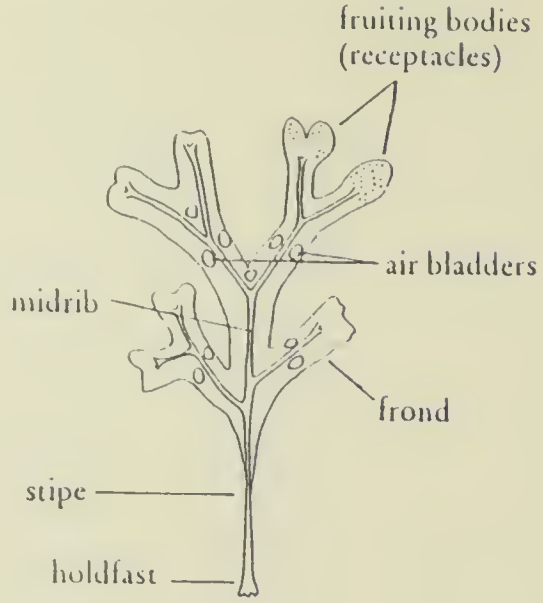
11b

IDENTIFICATION KEY TO MARINE ALGAE

after Quigley & Crump (1986).

Brown seaweeds (Phaeophyta)

KEY I



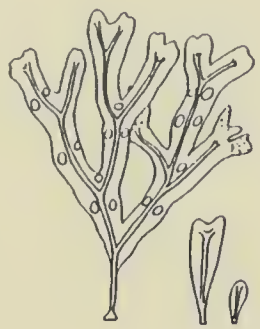
dichotomous branching

1 a Plant with obvious air-bladders. (Do not confuse bladders for swollen, gelatinous fruiting bodies at tips of frond or on stalks from the fronds.) ——→ 2

b Plant without air-bladders. ——→ 3

2 a Air-bladders commonly in pairs. Frond with distinct midrib; dichotomously branched. Yellow-brown to olive-brown; up to 1 m long (usually shorter). Middle part of sheltered shores.

Fucus vesiculosus
Bladder Wrack



Young Fucus species

b Single, egg-shaped bladders arranged at intervals along frond; branching irregular. Stalked, sultana-like fruiting bodies arise from sides of frond in spring and early summer. Olive-brown; 60 cm to 2 m long. Middle part of sheltered shores.

Ascophyllum nodosum
Egg Wrack

Epiphyte — *Polysiphonia lanosa*

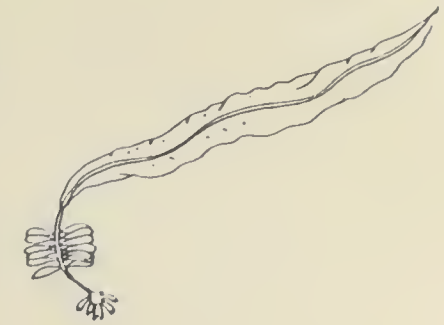
3 a Frond with a midrib. ——→ 4

b No obvious midrib down centre of frond. ——→ 7

4 a Frond branched. ——→ 5

b Frond unbranched; easily torn; edge wavy; midrib distinct. Base of stipe with bunches of leaf-like structures when fertile. Yellow-brown with yellowish midrib; up to 2 m long. Lower shore and below on very exposed coasts.

Alaria esculenta
Dabberlocks



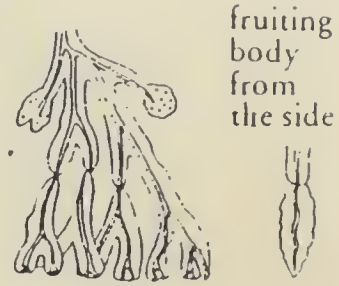
5 a Frond flattened with serrated edge. Tips of branches with flattened, pointed fruiting bodies in autumn or winter; up to 60 cm long. Lower shore on all but very exposed coasts.

Fucus serratus
Serrated Wrack

b Edge of frond not serrated. ——→ 6

6 a Plant hangs from rock surface. Upper shore; sheltered sites. Fruiting bodies have clear margin — granules do not reach edge. Frond tends to develop elongated blisters.

Fucus spiralis
Spiral Wrack



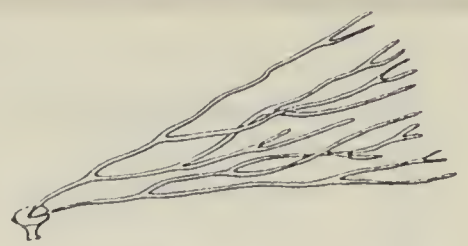
b Plant stands on rock surface. Middle shore; exposed sites. Granules reach margin of fruiting bodies. Blisters do not form in frond.

Fucus vesiculosus var. linearis
Bladderless Bladder Wrack

7 a Frond branched. ——→ 8

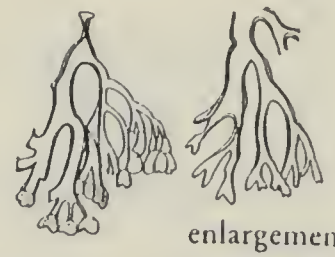
b Frond entire or split longitudinally but not branched. ——→ 9

8 a Plant small, mushroom-like. In summer: long, strap-like reproductive organ up to 3 m long. Lower shore and below.



Himanthalia elongata
Thongweed

b Frond in-rolled along edge, channelled on underside; tips often swollen and granular. Forms tufted bunches which hang downwards on rock on upper shore. Dark olive-brown, black when dry; up to 15 cm long.



enlargement showing channels

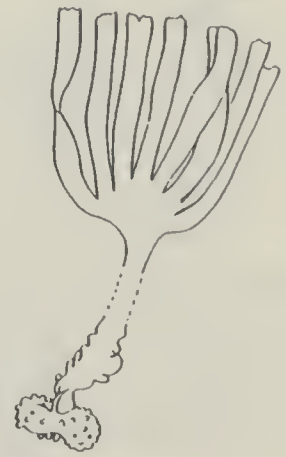
Pelvetia canaliculata
Channel Wrack

9 a Frond entire with transverse crinkles. Yellow-brown; from 30 cm to 2 m long. Middle shore and below; in pools, attached to rocks.

Laminaria saccharina
Sea Belt

b Frond a broad flat sheet split longitudinally. → 10

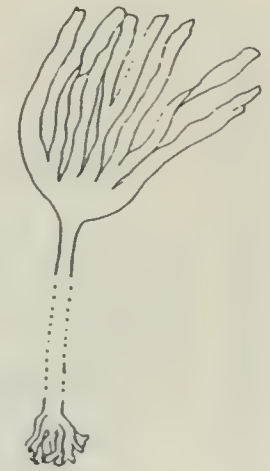
10 a Holdfast large, bulbous and hollow; surface warty; stipe flattened and twisted with broad wavy frills along lower edges. Up to 2 m long. In sublittoral zone, not forming belts.



Saccorhiza polyschides
Furbelows

b Holdfast root-like, appearing as a claw. → 11

11 a Stipe flexible and crushes when bent; smooth; oval in section. Stipe not covered with red seaweeds (epiphytes). Up to 2 m long. Forms a distinct belt on the lower shore.



Laminaria digitata
Oarweed

b Stipe rough, stiff, hard and circular in section. Often covered with red seaweeds (epiphytes). Expands abruptly into a broad frond, up to 3 m long. Forms distinct belts on the lower shore and sublittoral zone.

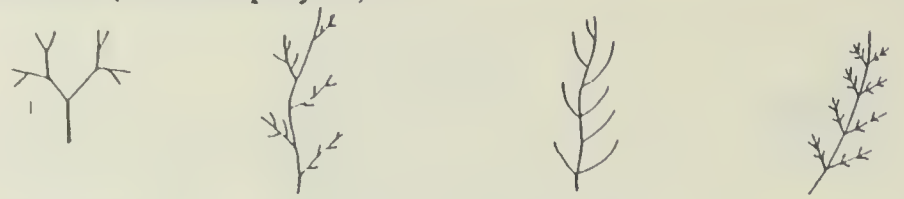
Laminaria hyperborea
Cuvie

c Similar in characteristics to *L. hyperborea* but without red seaweeds (epiphytes) on stipe. Sublittoral zone on south-west coasts.

Laminaria ochroleuca

Red seaweeds (Rhodophyta)

KEY II



dichotomous | alternate | irregularly alternate | opposite

If your specimen of red seaweed does not key out here and you wish to continue your identification we suggest that you consult Hiscock (1986). See Bibliography.

1 a Encrusting patches (shades of red to black) or **moss-like carpet** under other seaweeds or in crevices. → Page 44
b Plant of other form. → 2

2 a Thallus (plant body) flat or sheet-like, margin entire or divided. → Page 44
b Thallus branched in a variety of ways. → 3

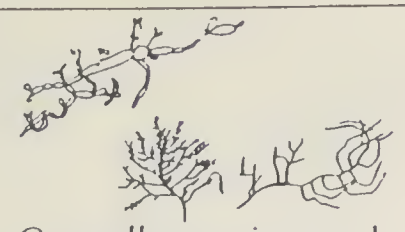
3 a Main branches regularly dichotomous (or nearly so). → Page 45
b Branching of different pattern. → 4

4 a Main branching regularly or irregularly alternate. → Page 46
b Main branching either opposite or irregular. → Page 46

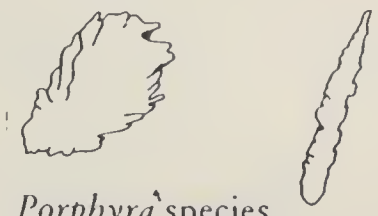
Encrusting patches

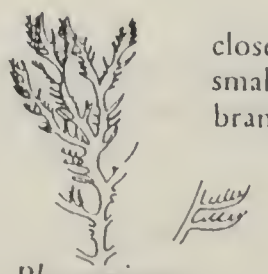
Texture	Form/colour/location	Genus/species
Chalky	Of more or less concentric rings with knob-like or leaf-like outgrowths. Patches may be extensive. Pink to purple, white when dead. Middle-to-lower shore.	Encrusting coralline algae
Velvety, of fine threads	Fine crimson-to-dull-red mats, binding sand.	*Audouinella floridula*
Smooth and glossy	Extensive crust (can be lifted with a finger-nail). Dark red. Middle shore and below in damp, shady places.	*Petrocelis* species
	Thin (too thin to be lifted with a finger-nail). Lighter red. Throughout the intertidal zone.	*Hildenbrandia* species

Moss-like

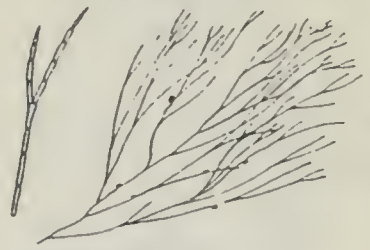
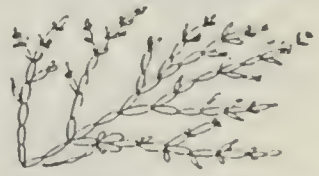
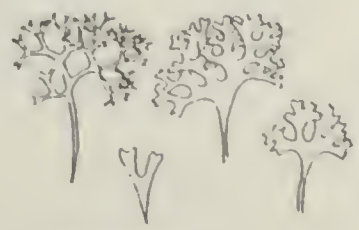
Texture	Form/colour/location	Genus/species
Soft	Interlacing, irregularly branched threads. Dark purple to black. High on shore in crevices, under *Pelvetia canaliculata* and *Fucus spiralis*. Do not confuse with black fruticose lichens	 *Catenella caespitosa* and *Gelidium pusillum* (lower)

Sheet-like: flat or lobed

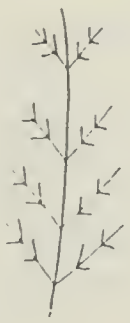
Texture	Form/colour/location	Genus/species
Thin but not delicate, like polythene	Like sheets of polythene; translucent; margins lobed or split. Purple, yellow-green or black; purple when dry. Up to 30 cm long. Exposed shores at all shore levels.	 *Porphyra* species
Thick, opaque, not like polythene	Blades broad or narrow. Margin entire or cut into finger-like ribbons. Often with small ribbon-like pieces growing from the margin. Up to 30 cm long. Bright-to-dark red. Middle shore and below.	*Palmaria palmata*
Tough and leathery, up to 1 mm thick, opaque, not like polythene	Blades wedge or spoon shaped; up to 30 cm long and 20 cm wide; older blades split. Several fronds usually arising from the same base. Dark red. Lower shore and below.	*Dilsea carnosa*

Branching pattern	Form/colour/location	Genus/species
Regularly dichotomous (or nearly so)	**Midrib present** Thin, flat ribbon with leaf-like branches and blunt-tipped branchlets. Up to 20 cm long. Thin parts often worn away towards base. Deep pink. Lower shore and below, usually in deep pools during the summer.	*Membranoptera alata*
	Midrib absent: main axis and branches of cylindrical threads Attached to *Ascophyllum nodosum* and sometimes *Fucus* species (see page 42). Tufted with tips outspread. Up to 8 cm long. Dark reddish brown. Middle shore.	*Polysiphonia lanosa*
	Tips of branches sometimes divided into two in-curved hooks. Branches often with alternate light and dark bands. 2–20 cm long. Deep red to yellowish green. Lower shore and below, on rocks and in pools. close-up of tip	*Ceramium* species
	Branchlets comb-like, on alternating series of three to six branchlets each side. Usually flattened in one plane but may become bushy. 2–15 cm long. Dark-to-rose red. Lower shore in pools and below.  close-up of smaller branches	*Plocamium cartilagineum*

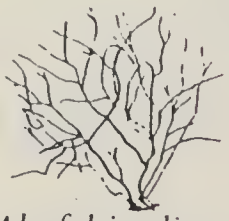
Thallus branched

Branching pattern	Form/colour/location	Genus/species
Regularly dichotomous (or nearly so)	**Midrib absent: main axis and branches of cylindrical threads** Tips of branches simple, tapering to fine points. Individual cells very large (can be seen with the naked eye). An erect tuft underwater. 8–20 cm long. Pink-crimson. Lower shore pools and below. 	*Griffithsia flosculosa*
	(A number of *Polysiphonia* species may key out here. We suggest that you consult Hiscock (1986). See Bibliography.)	
	Midrib absent: main axis and branches of sausage-shaped sections Plant soft, hanging limply from rocks and other seaweeds. 8–10 cm long. Bright red-crimson. Lower shore and below. 	*Lomentaria articulata*
	Midrib absent: main axis and branches flattened, with a disc holdfast Thallus coarse, in-rolled, short branches twisting. Surface may be dotted with small, raised knobs. 10–20 cm long. Dark brownish red. Middle and lower shore on rocks and in pools. (Do not confuse with upper shore brown seaweed, *Pelvetia canaliculata* (see page 43).)	*Mastocarpus stellatus*
	Thallus with short, flattened stalk. Very variable in form. Usually fan-like with small rounded branches. 8–16 cm long. Dark-to-crimson red; blue-violet iridescence when in water. Middle shore and below. 	*Chondrus crispus*

Thallus branched

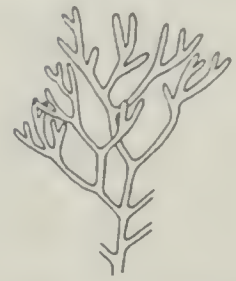
Branching pattern	Form/colour/location	Genus/species
Regularly alternate	(A number of *Polysiphonia* species may key out here. We suggest that you consult Hiscock (1986). See Bibliography.)	
	Branched in one plane; main stalk strong; oval in section. Smaller branches blunt ended; fronds thick and fleshy. Variable in form from large (up to 20 cm), scraggy and much-branched in rock pools to short and stubby in exposed situations. May form a tuft. Purple-red to olive; bleached to yellow in summer. Middle and lower shore.	*Laurencia pinnatifida*
Irregularly alternate	Branched all round; branch ends blunt and stubby. Branches cylindrical or slightly compressed. Dark purple to greenish yellow. 10–15 cm long. On open rock, occasionally in pools. Mid-to-lower shore. Often with *Laurencia pinnatifida*.	*Laurencia hybrida*
Opposite 	See *Laurencia hybrida* above.	
	Plant stiff consisting of small, limy sections (longer than broad). Up to 10 cm long. Colour variable: purplish red-pink, becoming chalky white when dead. Middle shore and below on shaded rocks and in pools. May branch from base and become tufted.	*Corallina species*

Thallus branched

Branching pattern	Form/colour/location	Genus/species
Irregular	**Plant tubular (hollow)**	
	Gelatinous; very soft and slippery. Sparingly branched at base; forms clumps of twisted, hollow tubes. Branchlets narrow at point of origin with slight constrictions along length; tips blunt. 6–30 cm long. Purplish red to yellowish. Middle shore and below on rocks and stones.	*Dumontia contorta*
	Stem and main branches cylindrical: disc holdfast	
	Rather elastic and stretchy in texture. Branchlets taper at their bases and free ends. Small wart-like knobs scattered over plant in summer. 7–50 cm long. Red-purple-black. Middle shore and below on rocks and in pools.	*Gracilaria verrucosa*
	Stem and main branches cylindrical: claw holdfast	
	Soft and bushy, branches narrowest at point of origin and taper to a point. Attached to substratum by a claw-like holdfast. Swellings occur on branches during the summer. 15–45 cm long. Purple-red to straw colour. Middle shore and below on rocks and in pools.	holdfast *Cystoclonium purpureum*
	Tangled, wiry threads	
	Plant 15–30 cm long. Appears black. Middle shore and below in pools, especially in areas near sand.	 *Ahnfeltia plicata*

Green seaweeds (Chlorophyta)

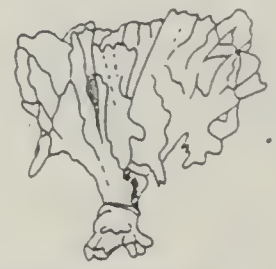
KEY III



1 a Plant with the texture of felt; dichotomously branched; branches round in section. Dark green. Up to 30 cm long. Found in deep pools; middle shore and below.

Codium species

b Plant without the combined features of the above. ——▶ 2



2 a Plant a thin, irregularly shaped, translucent, smooth, broad membrane. Up to 30 cm in length, usually much shorter. On most parts of the shore.

Ulva species

b Plant narrow; either tubular or thread-like; branched or unbranched.—▶ 3

3 a Plant tubular (roll between fingers); may be branched. Up to 30 cm long. Common throughout intertidal zone, particularly where freshwater is present.

Enteromorpha species

b Plant thread-like. ——▶ 4

4 a Plant unbranched, forming a tangle of threads. Up to 30 cm long, but often shorter. Common in intertidal zone and below.

Chaetomorpha species

b Plant branched. ——▶ 5

5 a Plant densely tufted; often coarse and wiry. Up to 10 cm long. Middle shore and below.

Cladophora species

b Plant of feathery appearance; branches divided into numerous branchlets. Up to 10 cm long. Middle shore and below.

Bryopsis plumosa

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